Near-Surface Disposal Strategic Position Paper

August 2020

Background

Managing radioactive waste is one of the main challenges in the NDA's clean-up mission at its 17 early nuclear sites. Waste types vary widely in terms of quantity, hazard and characteristics.

The UK Radioactive Waste Inventory (UKRWI) contains data for more than 1,300 individual waste streams that have arisen since the earliest days of the nuclear industry and continue to be produced. The management of radioactive wastes involves a number of key stages: planning and preparation; treatment and packaging; storage and disposal.

Disposal is the final stage of the waste management lifecycle and is the emplacement of waste into an appropriate facility with no intention to retrieve it. The timely availability of fit-for-purpose disposal capability is essential as it enables the NDA to deliver its mission and provides a final solution for waste generated from decommissioning and clean up.

The UK benefits from several existing disposal sites for Low Level Waste (LLW) waste; including the Low Level Waste Repository (LLWR), Dounreay Low Level Waste Disposal Facility and a small number of sites operated by the supply chain. Radioactive Waste Management Limited (RWM) is responsible for the design and construction of GDF. The deep, protective isolation of a GDF will always be necessary for much of the waste in England and Wales that has higher or long-lived levels of radioactivity, e.g. High Level Waste (HLW). However, other disposal options may be suitable for less hazardous material.

The NDA identified a potential gap in the UK's disposal system. The NDA believes that there is a proportion of Intermediate Level Waste (ILW) that could be more appropriately managed in near-surface disposal (NSD) facilities and initiated an investigation to explore the technical feasibility of this disposal capability.

This exploratory work supports UK government policy, which requires us to consider other disposal options, as well as a GDF, that could potentially improve our overall long-term management of Higher Activity Waste (HAW). The policy was developed following earlier recommendations by the government's independent Committee on Radioactive Waste Management (CoRWM). Scottish Policy for the management of HAW is long-term management in near-surface facilities, which is supported by an associated implementation strategy. The NDA continue to support Scottish government and we plan to investigate earlier opportunities for the implementation of NSD solutions in Scotland.

We committed, in our 2016 NDA Strategy document and 2019 Radioactive Waste Strategy, to exploring a range of possible NSD options, working alongside our subsidiary RWM, site licence companies (SLCs) and the regulators.

Managing radioactive waste in the UK

Depending on overall radionuclide levels, solid wastes are generally sorted into the broad categories of Low Level Waste, Intermediate Level Waste and High Level Waste. Although useful, these categories do not reflect the full nature or risks posed by the waste.

Dealing with radioactive waste involves detailed planning and preparation; most wastes require treatment and packaging prior to either storage or disposal. Storage and disposal can be described as:

- **Storage:** Interim facilities will store certain waste types until a suitable disposal route becomes available. Storage may last from a few months to many decades.
- **Disposal:** This involves placing wastes into engineered facilities where they will remain permanently.

Wastes may need transporting for treatment, packaging, storage and disposal.

Transport is usually by road or rail and is subject to strict conditions. Some radioactive waste can be treated for re-use or recycling.

The total mass of radioactive waste (reported at 1 April 2016), including forecasts up to 2125, is about 4.9 million tonnes. By comparison, the UK currently produces about 200 million tonnes of conventional waste each year, including 4.3 million tonnes of hazardous waste. More than 90% of radioactive waste is LLW, mostly a result of dismantling existing nuclear facilities and cleaning up sites. Less than 10% (310,000 tonnes) of radioactive waste is ILW and about 0.06% (3000 tonnes) is HLW.

Nearly three-quarters of all UK radioactive waste is from Sellafield in Cumbria. Magnox power station sites and Springfields in Lancashire are the next largest producers. Looking forward, the NDA's radioactive waste management programme is changing. Bulk quantities of radioactive waste are starting to be removed from Sellafield's oldest facilities, vitrification of HLW is drawing to a close and we will need to start dealing with large volumes of waste from dismantled facilities. Effective waste management will be essential, as these waste streams have materials that will cross between the boundary of low and intermediate level waste where we adopt a risk-informed approach. A proportion of wastes from our decommissioning programmes could be suitable for NSD. Currently, all HAW from UK nuclear sites is either stored in its raw state or retrieved, conditioned and/or packaged into a form suitable for interim storage pending availability of a final disposal solution.

Disposal

Geological disposal

Deep geological disposal will always be required for a significant proportion of radioactive waste and spent fuels. A GDF would be developed underground in a stable rock formation. Waste is packaged in secure containers and placed in sealed vaults and tunnels, up to 1,000 metres below the surface.

This permanent disposal system provides the highest level of isolation in order to prevent radioactivity from ever reaching the surface in levels that could cause harm. The highly engineered multiple barriers will provide protection over hundreds of thousands of years.

Near-surface disposal

The disposal of radioactive waste in near-surface facilities is already used for LLW (LLWR in Cumbria and the Dounreay LLW facility). This option is currently limited to LLW. However, the NDA are exploring the benefits of developing similar facilities for disposing of some of the less hazardous proportion of ILW. We are assessing the technical, environmental and economic case for purpose-built engineered facilities located either at the surface or up to tens of metres below ground. If NSD is implemented, it would not replace a GDF and would be developed in tandem to provide an earlier and more cost-effective solution for a limited proportion of the less hazardous wastes in the ILW category. Although containing a very small fraction of the radioactivity within the radioactive waste inventory, this could nonetheless represent significant volumes of waste material. The diversion of any waste to a potential future NSD facility should only result in minimal impact on the overall design and operations of a GDF.

> "The development of NSD facilities could help to accelerate decommissioning and hazard reduction and provide increased flexibility within the waste management system, including, in some cases, reducing the need for interim storage."

The development of NSD facilities could help to accelerate decommissioning and hazard reduction and provide increased flexibility within the waste management system, including, in some cases, reducing the need for interim storage. A proportion of wastes planned for interim storage or currently in storage at Sellafield may be suitable for NSD, which would save the costs of constructing new stores. In addition, final site clearance of Magnox reactor sites is likely to generate a large proportion of wastes which may be more appropriate for disposal in an NSD facility.

Such an approach aligns with our Radioactive Waste Strategy that recommends risk-informed waste management and flexible decision-making, focused on the most appropriate treatment and disposal routes that take account of the risks posed by the nature of wastes rather than strict classification.

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Technical Near-Surface Disposal options

There are two main concepts for NSD; at-surface level NSD and at-depth NSD, several tens of metres below the surface.

As part of our work, we have examined four different options for near-surface ILW disposal facilities, each offering safe, secure isolation and containment for specific types of waste (see appendix for illustrations). All options would have an operational phase expected to last several decades while waste is transferred to the facility. This will be followed by preparations for closure and a post-closure phase of ongoing management, potentially stretching over hundreds of years. Common features of a facility would also include security fencing during the operational phase, an area for deliveries, equipment for removing packages from transport containers and buffer storage. Facility depth and dimension would vary according to local site conditions. The key differences between the options are the proximity of the disposed waste to the surface and the engineered containment system:

- **Disposal vaults at-surface level:** This is similar to the LLW Repository system where waste packages are stacked in shallow engineered concrete vaults up to the approximate level of the surface. The closure phase consists of an engineered cap installed over the vaults to prevent rain-water entering and inadvertent intrusion, ensuring that no harmful quantities of radioactivity reach the surface.

- **Disposal vaults several tens of metres below ground:** Waste would be placed in a series of rectangular vaults tens of metres (up to around 80 metres) below the surface. Waste would be placed via a crane spanning the vault space. The vaults would consist of multiple barriers, including waste packages, grout, walls and backfill material to provide secure containment and resistance to ground water. Once complete, an isolation layer would cover the waste together with thick reinforced inner and outer caps, mass backfill and earth landscaping. The disposal depth would protect against the impact of natural processes such as coastal erosion and the potential for inadvertent human intrusion, ensuring the waste is undisturbed for thousands of years, so that no harmful quantities of radioactivity reach the surface.

- **Disposal silos several tens of metres below ground:** Similar to the vaults, this option would be developed up to around 80 metres below the surface and suitable for weaker near-surface rock structures, where a number of conjoined cylindrical silos will offer greater structural strength than rectangular vaults.

As with the previous option, a multi-barrier containment would surround the packaged waste, which would be lowered remotely into place by a crane. Three levels of waste are currently being considered, separated by reinforced concrete floors. Once a silo is full, an isolation layer would cover the waste together with thick reinforced inner and outer caps, mass backfill and earth landscaping. The disposal depth would again protect against the impact of natural processes such as coastal erosion and the potential for inadvertent human intrusion, therefore ensuring the waste is undisturbed for thousands of years, so that no harmful quantities of radioactivity reach the surface.

- **Disposal caverns several tens of metres below ground,** accessed by a shaft or tunnel: As with the last two options, these would be constructed at the same depth to allow waste to be placed in rock caverns via horizontal tunnels that extend from the base of shafts. A surface reception area would receive waste where it would be loaded into a winding cage for lowering to the access tunnel below ground. Remotely operated equipment and/or fork-lift trucks would transport packages for stacking in one of the caverns. Each cavern would require independent multiple-barrier containment. Once full, each cavern is sealed and shielded. The disposal depth would again protect against the impact of natural processes such as coastal erosion and the potential for inadvertent human intrusion, therefore ensuring the waste is undisturbed for thousands of years, so that no harmful quantities of radioactivity reach the surface.

The surface vault option could potentially be impacted by natural processes such as coastal erosion, and depending on locations selected may therefore be more suitable for less hazardous ILW so that residual radioactivity does not impact humans or the wider environment.

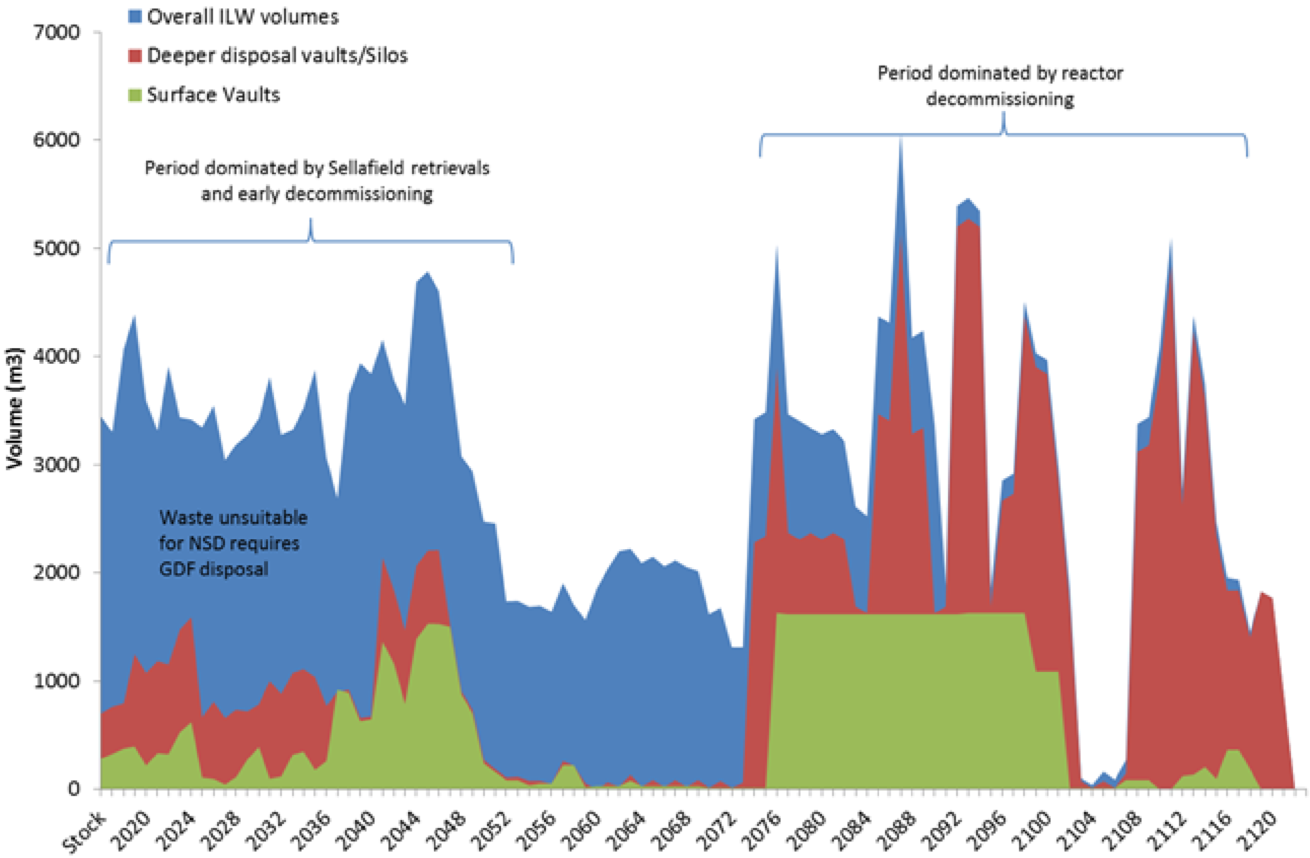
For the deeper options noted above, the waste is deep enough to remain under the sea bed in the event of coastal erosion. In these options, the containment would limit the release of radioactivity to the surface for many thousands of years. These options therefore allow a greater amount of radionuclides that decay slower, such as Carbon-14 (present in reactor graphite wastes) to be disposed of. Future glaciation could nevertheless potentially erode a NSD facility many thousands of years in the future; therefore amounts of very long-lived radionuclides such as uranium (found in fuel reprocessing wastes) would be restricted. When we initially considered the underground caverns in the near-surface, engineering experts advised that construction is likely to be much more difficult and could pose additional health and safety issues for the workforce. We therefore concluded that the caverns should be ruled out as a viable option at the present time although we will continue to keep possible options under review.

As the vaults at several tens of metres and the silos at several tens of metres were very similar, we considered these as a single option. If a site were to be developed, the choice between these two designs would be made using site-specific understanding of the geology.

Developing NSD up to the operational phase is estimated to cost approximately £45 million for surface vaults and approximately £325 million for the deeper vault/silo options.

Next Steps

Based on systems evaluated to date, we have assessed the types of waste that would be suitable and when they are likely to arise. The figure below shows the volume of waste that may be suitable for the two main near-surface options[1].



[1]Typically radioactive waste is referenced by volume not mass. We use volume to determine package numbers which ultimately dictates the size requirements of disposal facilities.

Much of the wastes being produced in the near term are associated with fuel reprocessing and will require deep geological disposal. Some of the other wastes produced in the near term could be disposed of in an NSD facility; the majority of these arise from early decommissioning at the Sellafield site.

When Magnox reactors are dismantled, much of the waste could be disposed of in the deeper disposal vaults/silos. This could include large-volume waste streams such as graphite from reactor cores. As a result of the change to the Magnox decommissioning strategy, and subject to a continual assessment of affordability and value for money by means of a business case at the time of implementation, it is the intention that some sites will be decommissioned earlier than previously planned. This will result in some wastes being generated sooner [1].

One option is to construct surface vaults to dispose of wastes arising in the near-term, while keeping open the option of a disposal silo for wastes from reactor dismantling. This provides an affordable solution focused on wastes that will be available for disposal in the nearer term[2]. Greater volumes of reactor dismantling waste could be diverted from a GDF if the deeper disposal silos were available in line with the Magnox decommissioning strategy. However, the development costs are high and we are not yet confident that this is an affordable solution in conjunction with a GDF (which will also be required for the disposal of the remaining ILW, the HLW and spent fuels).

Based on our investigations to date, it is the NDA's strategic preference to pursue NSD. Using a multi-project approach, with continued strategic oversight, a phased implementation of NSD could be possible as follows:

- Project I - develop surface vaults for a portion of current waste from the Sellafield programme. Such a facility may be expanded to support reactor dismantling
- Project II - later consideration of the option of an additional facility for wastes from the reactor dismantling programmes. Consideration could also be given to whether disposal vaults/silos should be developed to complement the GDF
- Project III - apply the NSD concepts to Scottish HAW, timed to meet the timescales identified in the Scottish government's implementation strategy

All work is exploratory only at this stage, however if taken forward, a new NSD facility could be available within the next 10 years.

Safety

Safety of both people and the environment is a priority at all times. As we continue to explore the technical features of NSD options, we are equally committed to demonstrating that any system selected would remain safe and secure, both during operations and at all times in the future including once a site is no longer actively managed. As NSD facilities will be closer to the surface, we are focusing on the containment barriers that will prevent waste from causing harm to people or the environment. These will be specific to a location and will take account of the potential for wastes to be disturbed, either through accidental human intervention or natural processes such as coastal erosion. The long-term safety performance is site specific and will be evaluated to develop the environmental safety case. The environmental safety case will assess the potential for the wastes to be disturbed by human and natural processes and, in such an event, ensuring that people and the environment are protected. An NSD facility would only be permitted on the basis of a robust environmental safety case.

[2]This information is based on UKRWI 2016. This position paper will be updated prior to final Strategy 4 publication with UKRWI 2019 information.

Other countries have already safely developed near-surface disposal facilities. These include the Centre de L'Aube facility, in France, which has been operating since 1992 for the disposal, in surface vaults, of LLW and short-lived ILW, and the VLJ repository in Finland which takes LLW and ILW in silos 60-100 metres below ground. RWM are responsible for carrying out research specifically looking at international examples of disposal of HAW. Further information can be found in 'Geological Disposal - Review of Alternative Radioactive Waste Management Options' [2].

Benefits

We are committed to considering opportunities that reduce environmental impacts, shorten timescales for decommissioning and site remediation and improve value for taxpayers' money.
NSD has potential environmental and cost benefits, while reducing risk and hazard, by:

- providing a new waste route for some HAW, in addition to a GDF, bringing greater flexibility to waste producers
- providing the opportunity for disposal based on the level of actual risk posed by the properties of the waste rather than strict waste classifications
- making disposal routes available earlier than the current baseline
- mitigating risks associated with existing/planned on-site storage, ahead of a GDF being available
- reducing volumes of waste planned for a GDF
- enabling some sites to be cleared earlier, freeing up land for another use
- reducing overall decommissioning costs

Assessment of savings that could be realised depend on which NSD option or options are selected, together with timings.

Location

Given this is exploratory work we have not identified a site or sites for a potential NSD facility. We have, however, identified criteria that could inform future site assessments, based on guidance from the Ministry of Housing Communities and Local Government for assessing the potential of sites for waste disposal developments.

The criteria are based on consideration of:

- water resources
- nature conservation and local heritage
- suitability of the local infrastructure for transport of workforce and wastes
- proximity of the potential site to the wastes that will be consigned for disposal
- climate and landscape change
- flooding

Prior to selecting a site, we would also consider if the potential land has been identified for alternative development either as part of site decommissioning, nuclear new build or other local plans.

Future Engagement

This strategic position paper has been produced to give interested parties an understanding of our initial work to investigate the potential benefits of NSD for a proportion of the ILW inventory. We recognise that effective engagement with all interested parties is required as work progresses and we will continue to engage on NSD, including throughout the Strategy 4 engagement and consultation process.

References

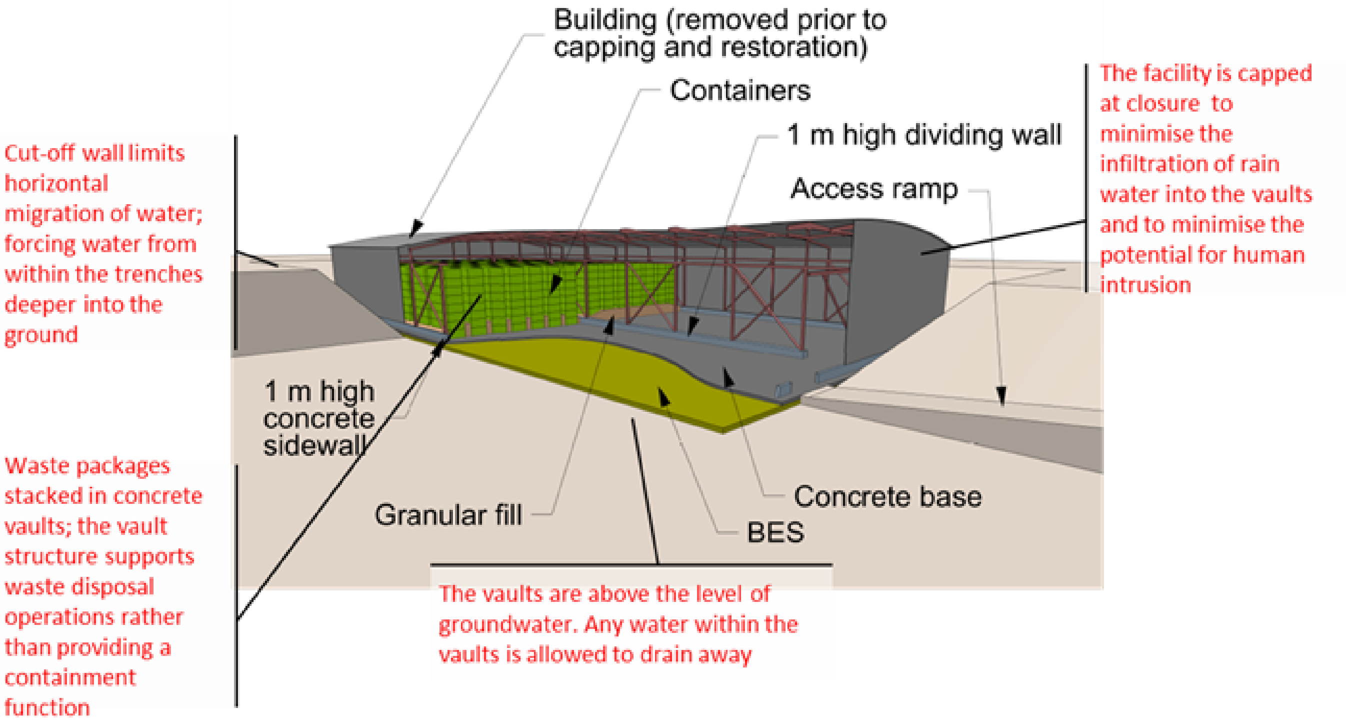
1. Strategy 4 – Consultation Document; Site Decommissioning and Remediation Strategic theme section.
2. ‘Geological Disposal - Review of Alternative Radioactive Waste Management Options’. March 2017, Radioactive Waste Management Ltd, NDA/RWM/146

Acronyms

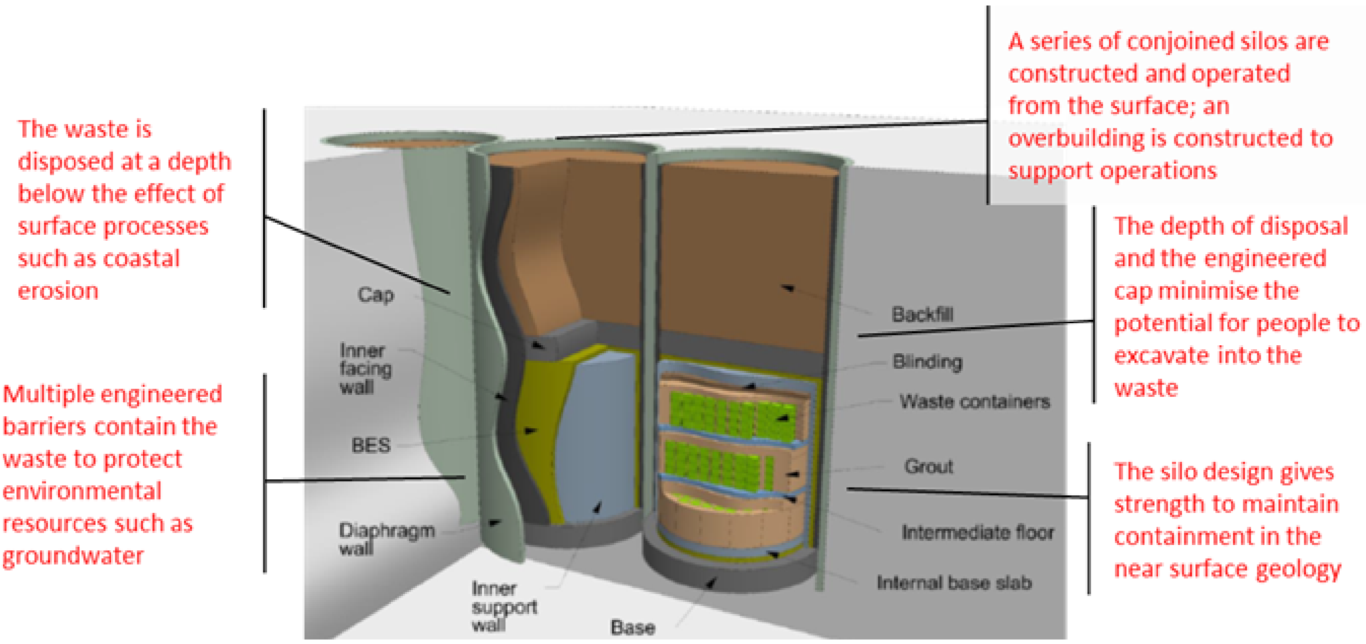
LLW	Low Level Waste
LLWR	Low Level Waste Repository
RWM	Radioactive Waste Management
NSD	Near-Surface Disposal
ILW	Intermediate Level Waste
HLW	High Level Waste
HAW	Higher Activity Waste
CoRWM	Committee on Radioactive Waste Management
SLC	Site Licence Companies
UKRWI	UK Radioactive Waste Inventory

Appendix - Illustrations of NSD Concepts

Surface vaults



Disposal silos at tens of metres



Vaults at tens of metres