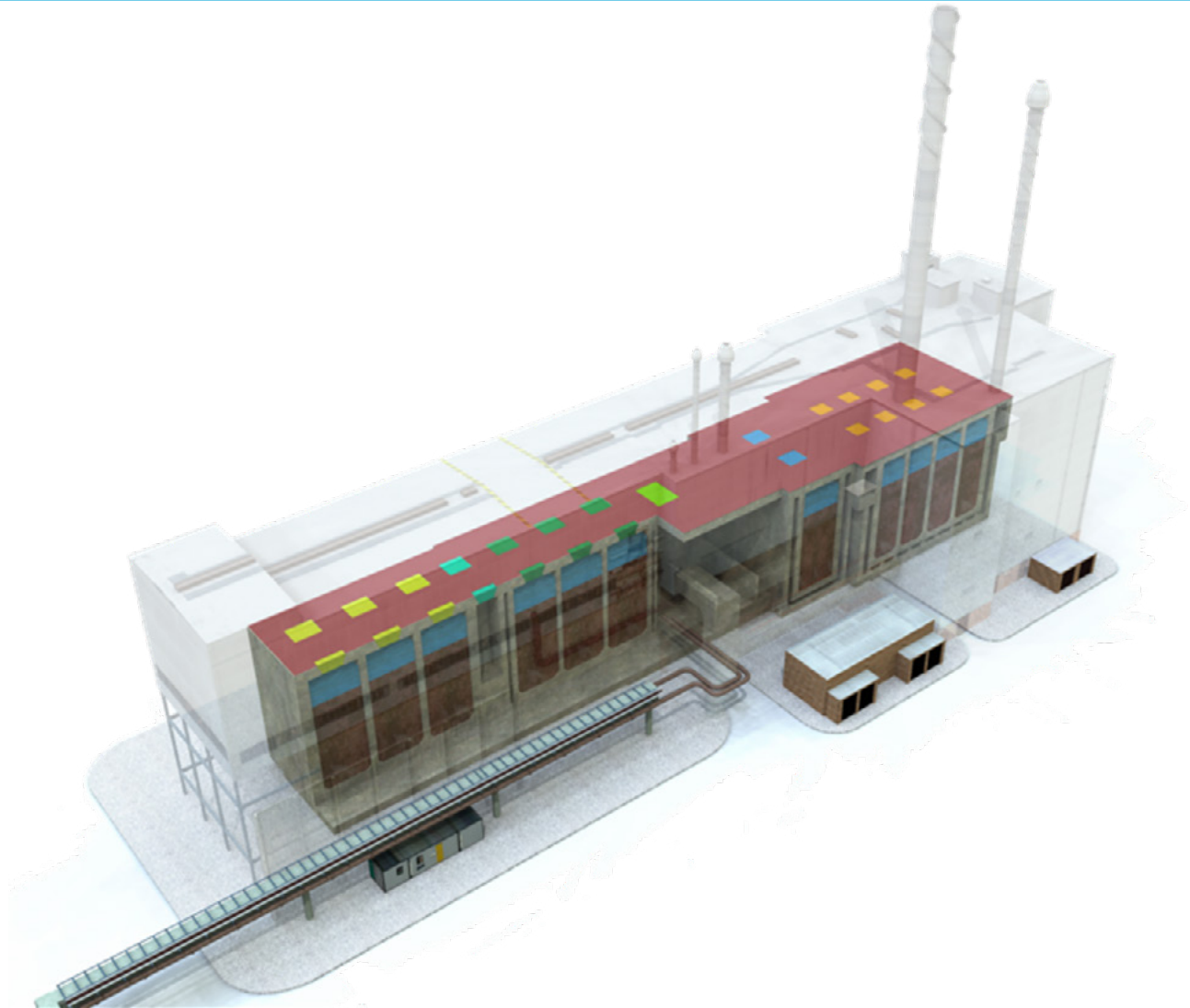




## CHALLENGE:

# Moving waste materials within storage silo compartments

Sellafield Ltd is seeking methods for radioactive waste retrieval from silo compartments that can either ensure no craters are formed in a waste bed during the retrieval process, or that can redistribute waste to prevent craters from becoming excessive in size and potentially hazardous.

## Introduction

A significant challenge in the decommissioning of Sellafield site is emptying storage silos containing radioactive waste. The Magnox Swarf Storage Silos (MSSS) contain approximately 10,000m<sup>3</sup> of solid material and the process of retrieving this material has already begun. The MSSS Original Building (OB) was constructed in 1962 and three subsequent extensions were added during the 1970s and 80s; their layout is illustrated in Figure 1. Most compartments are 6.4m square and approximately 16m tall, with each containing up to 600m<sup>3</sup> of solid waste, although the exact dimensions vary slightly for each extension. Some of the MSSS compartments contain fixed infrastructure that extends the full depth of the waste bed (Figure 2).

The waste content of each compartment varies, but can include:

- **Cover water** under which the radioactive waste materials are stored.
- Magnesium cladding that was stripped from Magnox fuel prior to fuel reprocessing, commonly referred to as “**swarf**”.
- **Sludge** that has resulted from the corrosion of swarf and consists mainly of magnesium hydroxide, uranium and uranium oxide.

- Large solid items, such as drums, that are referred to as **Miscellaneous Beta Gamma Waste (MBGW)**; these often float on the surface of the cover water.

MSSS contents are classified as Intermediate Level Waste (ILW) according to UK standards.

Access to each compartment, for either the addition or removal of waste materials, is via a central charge hole in the ceiling of the silo; this is accessed via the highly congested operations floor above the compartments. To date, the removal of waste bed material from the compartments has been performed by the **Silo Emptying Plant (SEP)**, described in the Current Practice section of this document. The SEP is only able to retrieve waste in the central area of a compartment resulting in the formation of a crater. The collapse of such a crater may result in the release of hydrogen gas, which could be hazardous or could trap the mechanical grab. Sellafield mitigates this risk by working under an inert atmosphere.

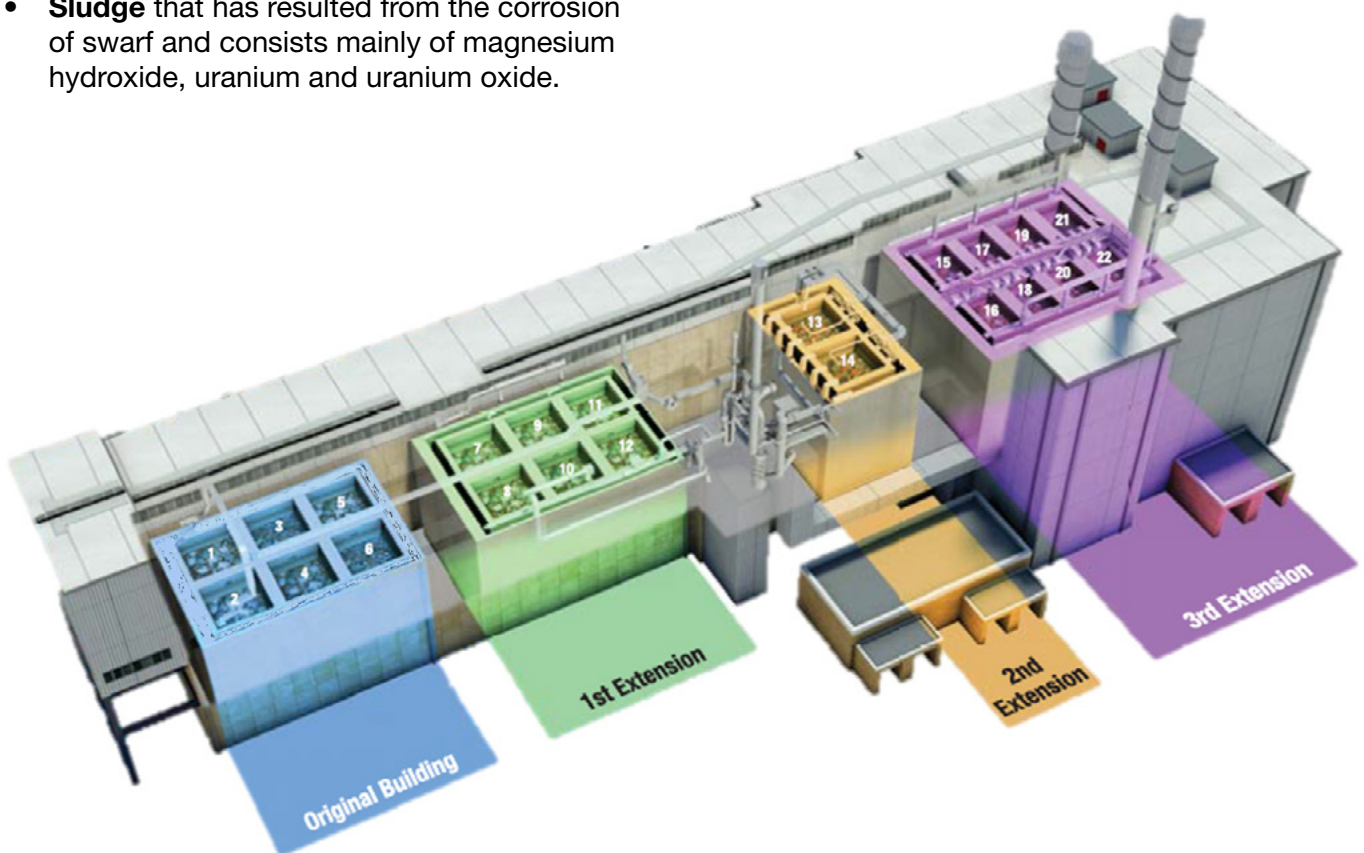


*Figure 1: Layout of silos in MSSS.*

Sellafield Ltd is seeking a new approach to managing the removal of this waste, which can either avoid craters being created in the first place or better manage them if they are created. Additionally, an accurate method to measure the waste bed profile could significantly improve the efficiency and risk management of waste removal operations.

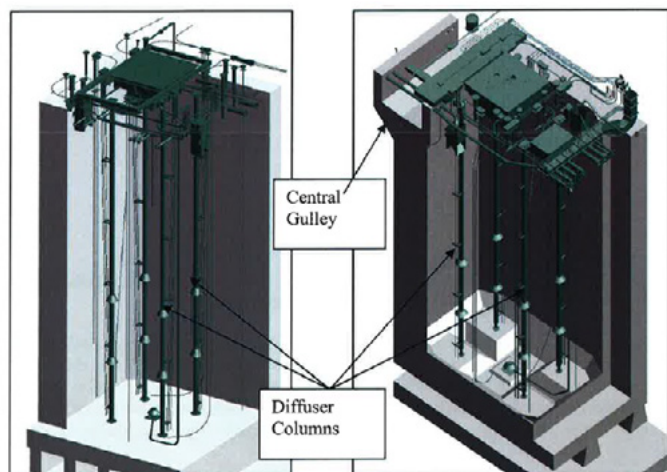


**Figure 2: Example layout of diffuser columns within silo compartment. Note, not all compartments have diffuser columns and so this will be the most challenging scenario.**

## Current Practice

The Silo Emptying Plant (SEP) is a mobile shielded unit that comprises a mechanical grab (Figure 3) suspended from a winch and a bay that contains a skip into which materials retrieved by the mechanical grab are placed. The SEP seals over a silo charge hole and the grab is lowered into the waste bed, where it indiscriminately picks up waste. The grab is then raised above the charge hole and the contents of the grab are deposited into the skip. Once the skip is full it is raised through the roof of the SEP into a transport flask that is connected to the top of the SEP. The following video provides a good overview of MSSS and the operation of the SEP: <https://www.youtube.com/watch?v=qQwky909RVQ>

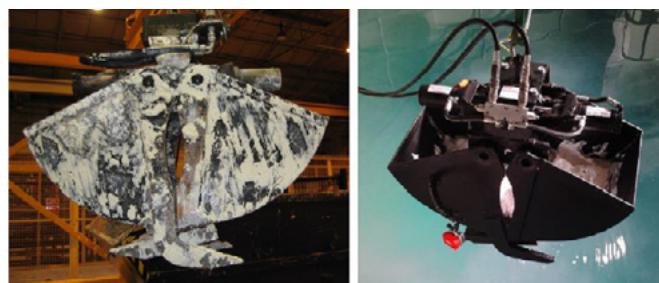
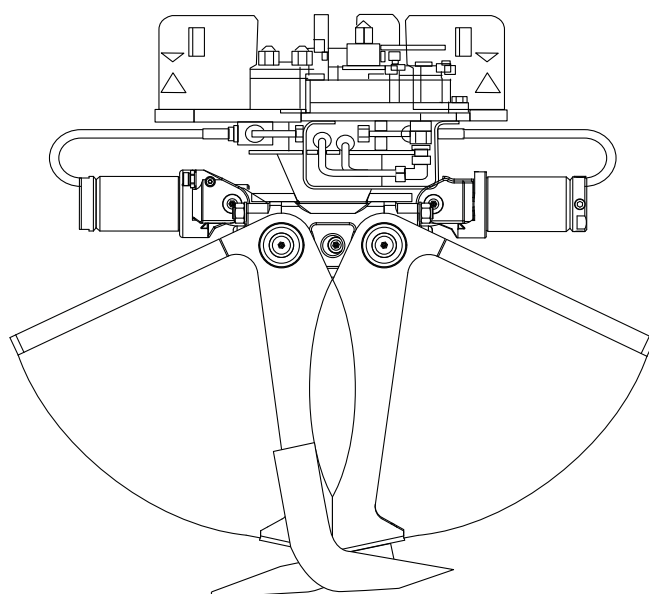


**Figure 3: Mechanical grab used to remove waste.**

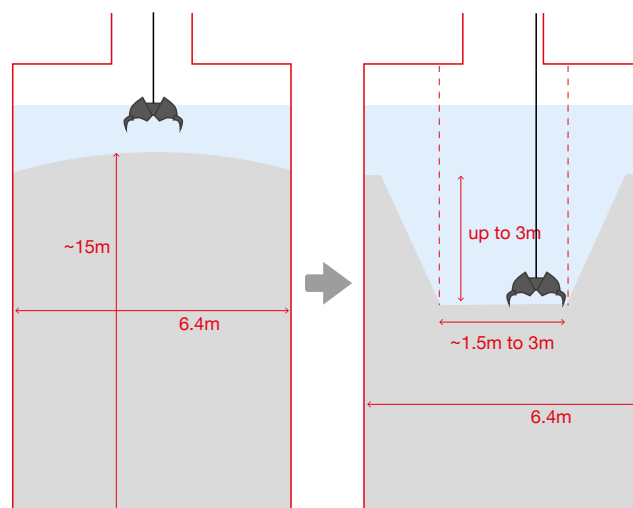


**Figure 4: Schematic of mechanical grab and crater formation.**

Waste material retrievals from MSSS have been progressing well for a number of years using the SEP; however, the reach of the grab within the silo is extremely limited in the horizontal plane. Within each silo, the reach of the grab is limited to an area directly below the charge hole measuring approximately 1.5m x 3m. This represents around 10% of the overall waste bed surface within each silo. As a result, current retrievals operations using the SEP are leading to the formation of craters in the centre of the surface of the waste bed as illustrated in Figure 4.

If a waste bed crater gets too deep, there is a risk that the sides may collapse inwards. A crater collapse could trap the mechanical grab, making it difficult or impossible to retrieve. For this reason, retrievals operations are currently limited to removing waste material from the waste bed to a maximum depth of 3 metres. The waste bed profile and crater depth are currently estimated via measurements of the level of the grab when its suspension rope becomes slack at various positions. This method is not able to provide information about the waste bed profile outside of the central area beyond the reach of the grab. These operations are all performed beneath the surface of cover water in the silo with zero visibility. The grab is required to retrieve the full waste bed.

Sellafield Ltd has explored options for mitigating against the formation of craters in the waste bed. A **second stage deployment (SSD)** system was designed to allow the grab to move in a horizontal plane beyond the limitations imposed by the charge hole. The SSD was intended to work in tandem with a **rake** that was initially designed to move surface waste material to provide access for the SSD. However, this solution was abandoned due to its cost and complexity.

Development of the rake component continued with the aim of pulling waste away from the periphery of the silo to fill the crater and provide accessible material for the grab. The rake design has two telescopic arms with end effectors that anchor into the waste and pull it into the central crater. When rotated in the horizontal plane, the rake could level the surface of the waste bed.

However, the following concerns about the performance and reliability of the rake cast doubt on this approach for the full depth of the compartments:

- Only able to operate in around half of MSSS silo compartments.
- Deployed via the SEP machine, so requires regular time-consuming tool changes.
- Lack of ability to visually assess the impact of a raking operation.

Deployment of a submersible Remotely Operated Vehicle (ROV) to pull waste material into the centre of a crater has been considered and tested, but concerns over lack of visibility in the silo and reliability have prevented progress on this front.

Where a crater has been formed, both the rake and the ROV rely on 'pulling' the material from the periphery of the compartment into the crater so that the SEP grab can subsequently retrieve the waste from the compartment. Sellafield Ltd recognises that 'pulling' the material may not be the only means of moving the waste. Examples of alternative movement methods include pushing material away from the compartment walls to the centre crater (i.e. using the compartment walls to provide a reactive force) and additional means of manoeuvring the grab within the compartment to the peripheral location for waste retrieval. These are two examples of alternative methods of moving waste and respondents are encouraged to consider other methods of mobilising material into the centre crater.

## Challenge Aims

Sellafield Ltd is seeking methods for waste retrieval from compartments that can either ensure no craters are formed in a waste bed during the retrieval process, or that can redistribute waste to prevent craters from becoming excessive in size. Currently, post processed sonar is being trialled to provide an accurate method to measure the waste bed profile, but a real-time solution could significantly improve the efficiency and risk management of waste removal operations.

The following benefits are of particular interest:

- Avoidance of crater formation.
- Maintenance of a reasonably flat/level waste bed profile.
- Capability to image and map the waste bed profile in real time.
- Ability to sustain the current rate of retrievals operations.
- Improving the efficiency of retrievals.
- Ability to support waste retrieval for the full depth of the compartment.

Sellafield Ltd is open to solutions that either improve the efficiency of current processes or are entirely new systems. The key is to enable predictable removal of waste material from the storage compartments.

## Benefits to Sellafield

Solving this challenge would provide the following significant benefits to Sellafield Ltd:

- The safety of the retrievals process would be greatly enhanced by removing the possibility of waste bed crater collapse.
- Real-time imaging/mapping of the waste bed profile would enable better operational planning.
- Better operational planning would lead to significant savings through improved grabbing efficiency, reduced downtime and improved skip filling.
- Any proposed solution should not agitate the waste such that the grab methodology is compromised. Improved performance in these retrievals processes would deliver increased Regulatory confidence.

## Constraints

- Access to compartments is as follows:
  - A limited number of 150mm diameter access ports, accessed via the operations floor.
  - Charge hole, which is rectangular with dimensions 2.134m x 1.448m, and slab thickness of 1.295m.
  - Any SEP deployed solution would need to be introduced via a skip with internal dimensions 1.188m x 1.188m x 1.1m (l x w x h).
- The composition of waste in each compartment varies. Compartments contain fixed obstacles including thermocouple tubes and diffuser columns (Figure 2).
- Layout of access ports and obstacles such as diffuser columns are slightly different in each silo. Any solution must tolerate this variability.
- Any process that disturbs the waste bed must be conducted in an inert (Nitrogen) atmosphere.
- There is no visibility under the cover water in the compartments.
- Any equipment deployed within the storage compartments will need to be able to tolerate gamma radiation levels of ~ 6Gy/h during operation and up to 12Gy/h maximum dose rate.
- The pH of the waste bed and cover water is at least 10-11.
- The temperatures within the compartments range between 10°C and 40°C.
- Combustible material and ignition sources must be avoided.
- Lithium batteries cannot be used, but power sources can be made available from the operations floor above the silo. Tools deployed via the SEP could be either hydraulically powered using Renolin fluid or electrically powered.
- The operations floor is normally highly congested with people and equipment, so spatial constraints should be taken into account.

- It may be possible to leave modestly sized equipment in-situ within the compartments, although this would need to be considered carefully by the Sellafield team. Such items must not require regular maintenance and be easily replaced.

## Functional Requirements

- Solutions must be deployable via the existing silo access points (see Constraints for more details).
- Solutions must be compatible with existing retrievals operations and improve the efficiency and predictability of the waste retrievals operations.
- Sludge may have high shear strength, potentially above 30kPa.
- Any equipment or materials that enter the compartments must not have any adverse impact on the waste material or its effluent properties. For example, no organic materials or aluminium can be added to the compartments.
- Equipment may be left in-situ during retrievals operations from a silo, where suitable.
- In the event of equipment failure, the equipment must either be recoverable (strongly preferred) or be disposable to allow jettisoning into the silo.
- Reliable and consistent operation of any equipment is required for prolonged use within the challenging storage silo environment. Waste retrieval is expected to continue for 30 years.

## Find Out More

Game Changers are hosting a workshop for this challenge where delegates will have the opportunity to meet challenge owners. Details are available on the Game Changers website [www.gamechangers.technology](http://www.gamechangers.technology).

If you have new ideas or innovations which can be applied to address this challenge, we invite you to join us. If you'd like more information about the funding available through the Game Changers programme, please visit [Our Funding Process \(gamechangers.technology\)](http://www.gamechangers.technology).

**The deadline for applications for this challenge is 3pm on Thursday 28th August 2025.**

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