Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

CHALLENGE: Leak prevention or minimisation

Sellafield Ltd are seeking ideas, innovations and technologies that will deliver game changing solutions to prevent or minimise leaks from the Magnox Swarf Storage Silo (MSSS) Compartments 1 - 6.

Current leak rates are circa 1.5 – 2.5 m^3/d. It is desirable to reduce these as much as possible. At present, it is not possible to determine with certainty the precise location of the leak, or indeed the silo or silos (of the 6) that is leaking.

This call for innovation is open to applicants from any sector including industries such as oil and gas, mineral mining, chemicals and water.

Sellafield Ltd are seeking a proof of concept capable of deployment in a real environment as soon as practicably possible.

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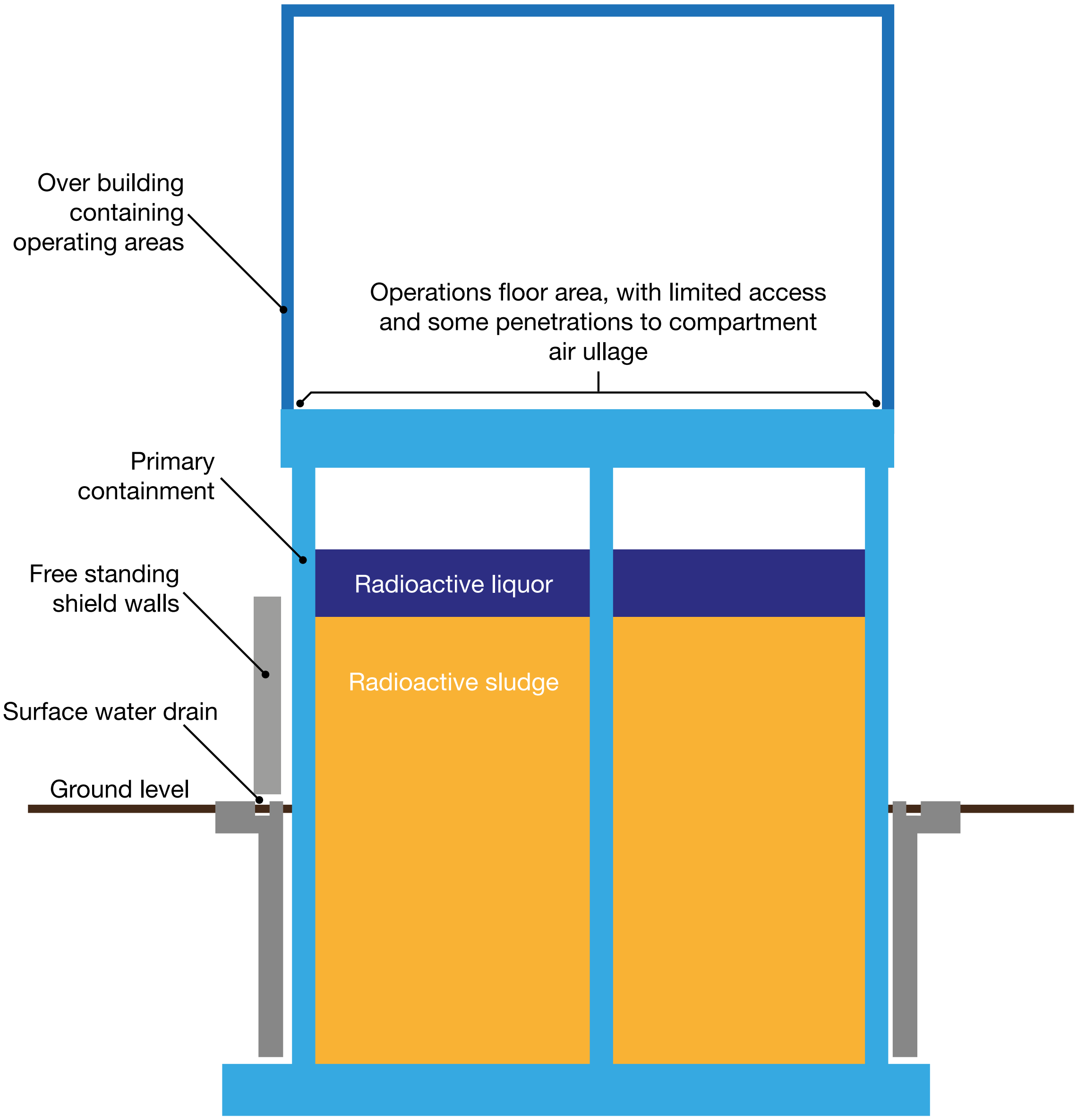
Introduction

The Magnox Swarf Storage Silos (MSSS) at Sellafield comprise an Original Building constructed in 1962 and three subsequent extensions constructed between 1972 and 1982. The silos contain magnesium cladding or 'swarf' that was stripped from Magnox fuel prior to reprocessing. The swarf is stored underwater in the silo structures, but over time the stored contents corrode, releasing heat and hydrogen meaning the facility requires constant management and monitoring. Historically, 'thermal excursions' have occurred within the contents, which significantly increased the temperature of the contents and adjacent structural elements in localized areas.

The construction of the Original Building silo is a reinforced concrete structure, comprising a 1.5m thick base slab with 1.4m thick external walls as primary containment, with no secondary containment. Internally, the silo is divided into six compartments in a 2 x 3 arrangement, each with internal dimensions of 6.4m x 6.4m x 16m deep. The compartments are covered by a 1.2m thick concrete slab which forms the operating floor, and the internal dividing walls between the compartments are 0.6m thick. **The original building is embedded in the ground by approximately 6m**, with complex infrastructure in places, making visibility and access difficult. Below ground, there is a bitumen layer around the concrete and a 300mm thick concrete wall between the silo and backfilled ground. Above ground, some of the external walls are obscured by free-standing shield walls.



Ageing concrete structures have been known to leak in the past and may have some cracks but these are difficult to identify and locate.

Cracks could be present in walls, floors and junctions. Waterbars are fitted at construction joints to prevent water ingress, but over time, materials may have become brittle and susceptible to fracture.

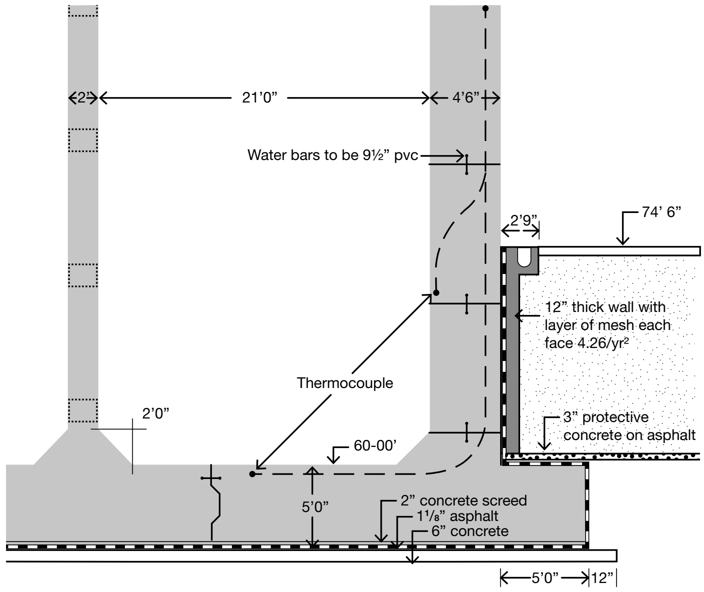
A common root cause of cracking in the concrete structures may be concrete carbonation, creating a lower pH environment and possible corrosion of the reinforcing steel within the concrete structure. It may also be possible for cracks to form as a result of compression and tension of structures, but this is not common. Structural performance of the building may be affected by the presence of cracking with the development of compressive and tensile stresses.

It is difficult to know where/if cracks are present due to the environment – for example, it is currently impossible to know whether there is a crack at **7m below the surface** in a radiation active environment. Generally, cracks are found at a horizontal or vertical construction joint which might help solutions hunt for cracks from drawings.

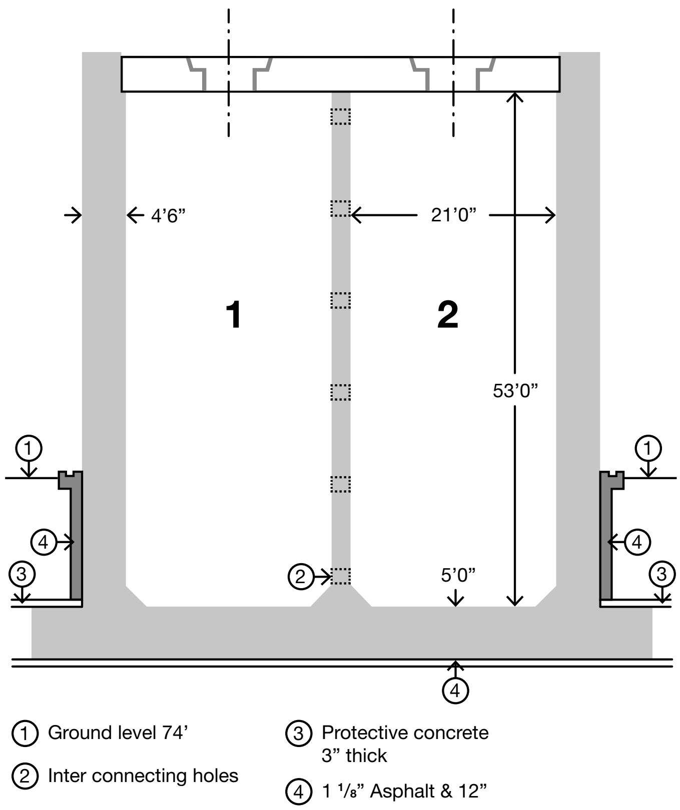
Where cracks occur, there is always the possibility that they may seep liquor, however, due to the depth at the location, subsoil pressure may maintain the structural integrity of the concrete structure and prevent washout or excessive leakage.

Current Practice

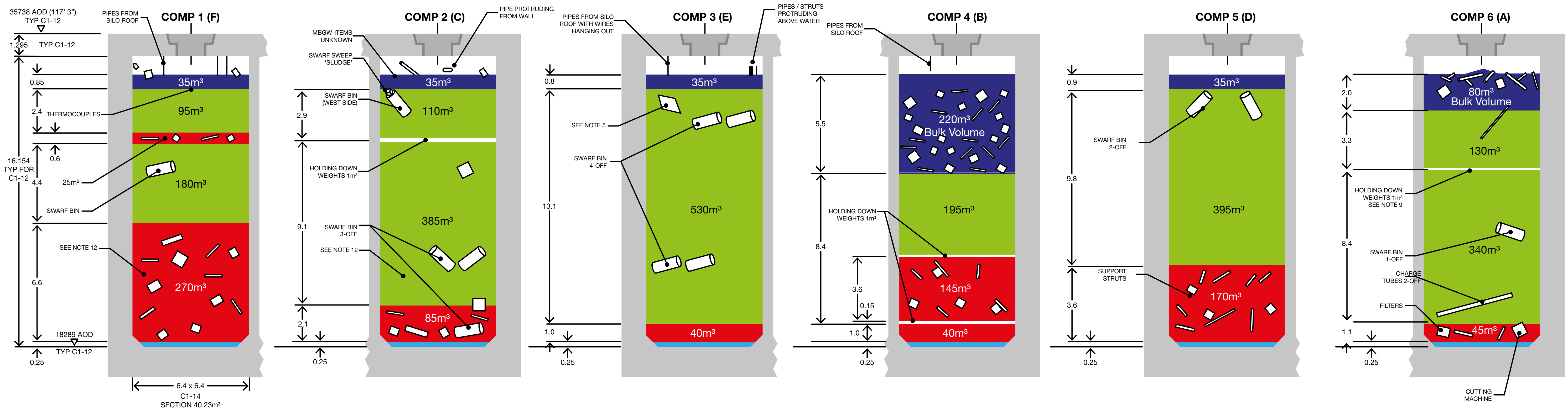
The silos are currently filled with predominantly magnesium hydroxide sludge, under a layer of cover water. The silos are just over 16m deep, of which the bottom 5m (approx.) are below ground level. ***The silos are interconnected via hydraulic links at six different levels – this means that the liquor can move between silos, although some of the links may be at least partially blocked.*** See figures on following page for details.



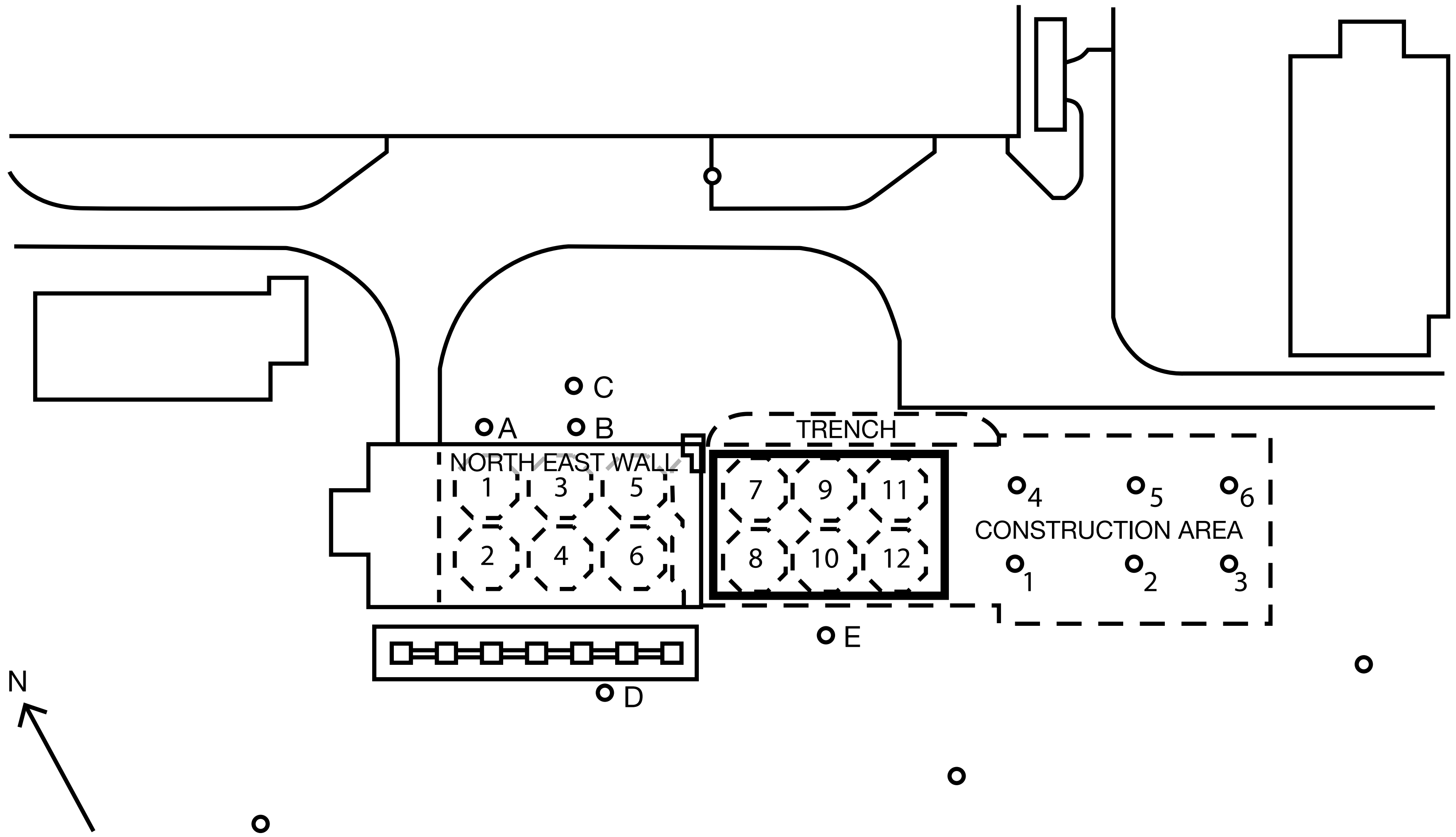
Detailed cross section of base
Not to scale



Cross section of compartments 1 & 2
Not to scale



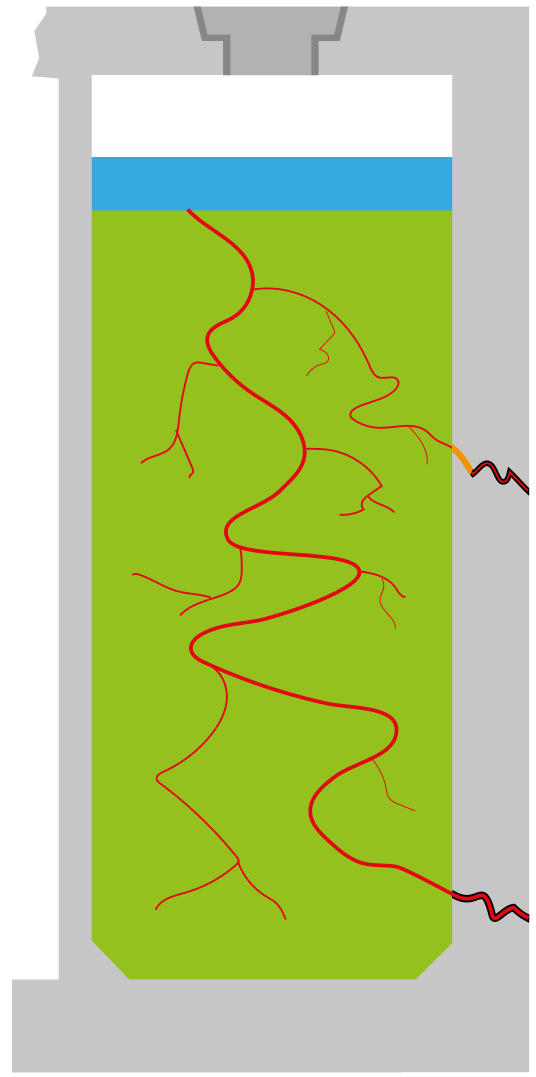
Key — Silo liquor · Swarf with some sludge · Sludge · Oxide fuel hulls · MBGW · 50mm washed limestone · MBGW & sludge · MBGW & silo liquor · Sludge with some swarf and decanned cave waste



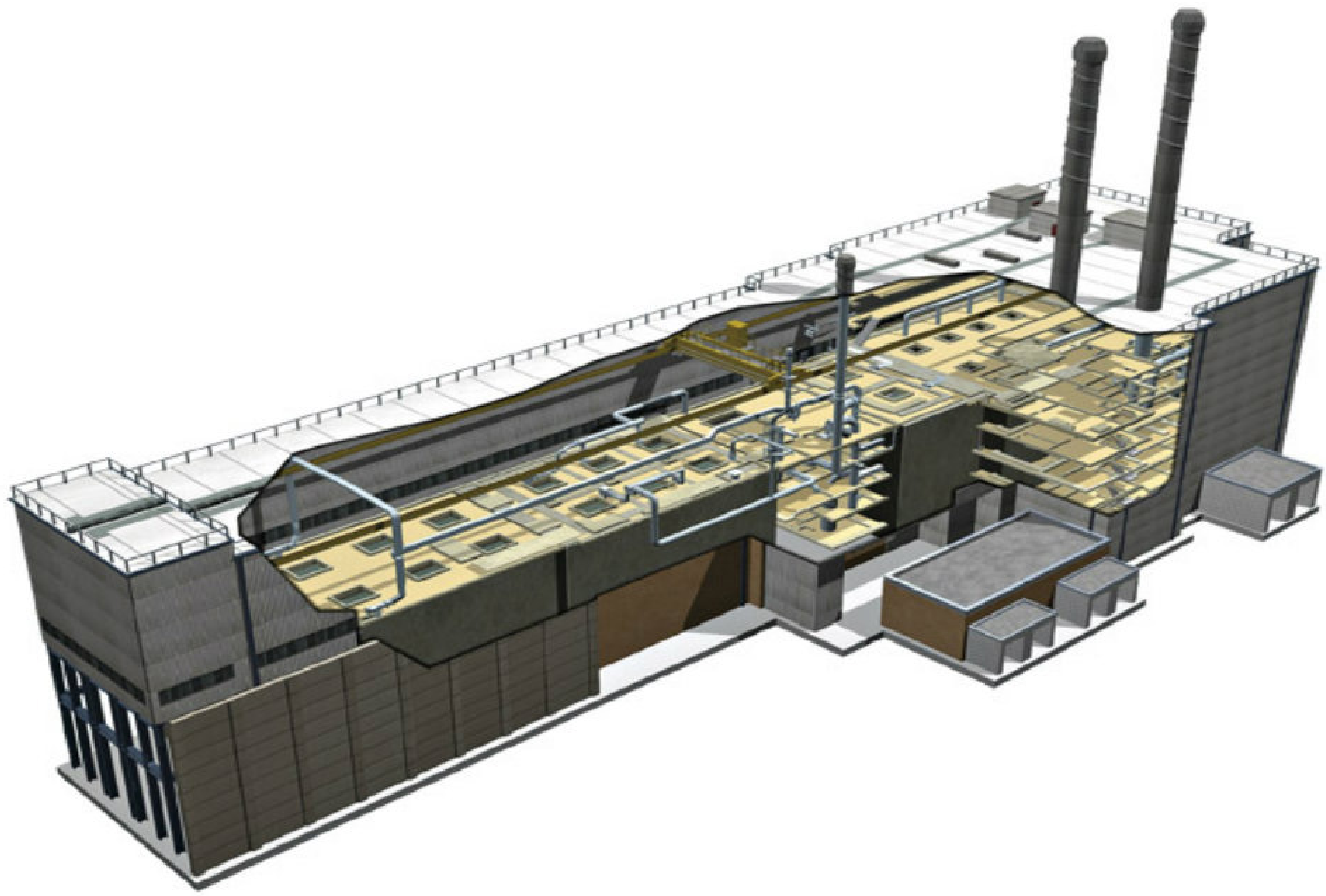
DE-NOTES BOREHOLE

Plan view of compartments 1 - 6 in "egg box" layout

A potential leak path through the bed of sludge is presented here, as an illustration.



Leak Site
NOTE - may be multiple sites



Challenge Aims

Current leak rates are circa 1.5 – 2.5 m^3/d. **It is desirable to reduce these as much as possible.**

NOTE 1 – solutions should be deployable from within the silos, rather than external to silos.

NOTE 2 – There is no constraint that the solutions must work under water cover – removal of cover liquor can be considered.

Opportunity

A solution to minimize or stop leaks in MSSS is sought. Successful applications will be funded at feasibility which may lead to further funding to create a proof of concept.

Intermittent monitoring of leaks and cracks will be carried out and further treatment to stop new leaks would be applied where appropriate. Over the next two years more load (e.g. 50T+ loads) will be added to the structure, potentially changing internal stresses accordingly.

The material retrieval process is expected to commence within the next 10 years in the silos. This process will involve material removal and de-watering of the silos. Sellafield Ltd need to have a solution to help them stop leaks as things change.

Benefits to Sellafield Ltd

Uncontrolled release of liquor to ground would be stopped, hence meeting key stakeholder requirements.

Sellafield Ltd will be able to move forwards through their plans to retrieve waste.

A solution may also have other potential application areas across site.

Constraints

- Surfaces of interest may be submersed at depth
- High pressures - 17m hydrostatic head
- Active environment (radiation)
- Water is cloudy, alkaline (around pH10) and parts of the structure are covered by radioactive sludge (up to 14m deep) and material

Functional Requirements

- Operate in a highly radioactive environment [100T Becquerels /m^3]
- Solutions can connect to the wall during deployment (subject to approval by Sellafield Ltd based on design and operational methods)
- Any chemical additives (if the solution demands them) must be deployable in such a way that any downstream effluent routes (aerial or liquid) accept effuents. For liquid effluents, this means meeting the Conditions for Acceptance (CfA) of the Sellafield Site Ion Exchange Effluent Plant (SIXEP). The same applies for CfA for intermediate storage of waste within skips
- Techniques should have a limited/minimal effect on retrievability of the waste

If you consider that you are strong in only one aspect of the challenge, we would still like you to put your application forward for consideration.

What next

Game Changers are hosting an online briefing webinar for this challenge. Details of the webinar will be available on the Game Changers website 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 www.gamechangers.technology/content/GameChangersFunding

The deadline for applications for this challenge is 1pm, 25 June, 2021.

Sellafield Ltd

Delivered by

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