Decommissioning of the Beta Gamma Waste Store, Sellafield UK – 11498

Jeremy Gareth Hunt
Sellafield Ltd, UK

ABSTRACT

A significant milestone was reached on 29th July 2010 at the NDA's Sellafield Site in the UK with the culmination of a 10 year programme of work to improve waste storage arrangements and to progress the decommissioning of one of the earliest legacy waste storage facilities on site.

The facility consists of 8 large shielded concrete cells that were filled to capacity with predominantly Intermediate Level Waste (ILW). Subsequently, following construction of an overbuilding over the cells, further wastes including ILW filters and drums containing Plutonium Contaminated Materials (PCM) were also accumulated within the building, resulting in increased dose rates and limited occupancy times for personnel.

As part of the programme to decommission legacy areas of the site and in line with the requirements of the Nuclear Installation Inspectorate, a detailed programme of work began in the year 2000 to make improvements to the waste storage arrangements and decommission the facility.

INTRODUCTION

This facility dating from the earliest part of Sellafield's history was originally destined to house sand bed filters for the Low Active Effluent Treatment System. However, the plant was never used for this purpose due to the development of other effluent management processes. The concrete shielded structures were used instead as an interim store for the miscellaneous beta-gamma waste arising from the site's Magnox fuel reprocessing operations.

The cells were filled to capacity with predominantly Intermediate Level Waste (ILW). A typical cell is shown in Figure 1. Subsequently, following construction of an overbuilding over the cells, further wastes including ILW filters and drums containing Plutonium Contaminated Materials (PCM) were also accumulated within the building as shown in Figure 2, resulting in dose rates rising to 6mSv/hr gamma and limiting occupancy times for personnel.

Fig. 1. Typical contents of the concrete storage cells filled with Low and Intermediate Level Wastes.

Fig. 2. Accumulation of ILW and PCM waste items in the Inter-Cell areas.

In August 2000, the UK nuclear regulator, HM Nuclear Installations Inspectorate issued a series of Regulatory instruments requiring short, medium and longer-term improvements to storage arrangements for Intermediate Level Wastes and Plutonium Contaminated Materials which had been accumulated in this and other facilities [1].

Sellafield Ltd developed a detailed programme of work to meet the requirements of the License Specification by 1st August 2010, ultimately resulting in the creation of a modern engineered store for the Intermediate Level Wastes within the cells, closing out the short-term improvements required by the regulator. These elements of work were delivered as the first and second phases of the project.

The third phase of the project addresses the medium to long-term improvements through a programme of work to characterise the contents of the 8 cells, followed by a combination of manual and semi-remote operations to segregate, retrieve and dispose of the wastes in accordance with the waste hierarchy and ALARP principles.

PHASE 1 – RETRIEVAL OF INTER-CELL WASTES

The first phase of the project was to deal with the accumulation of ILW and PCM waste items that had been accumulated in the inter-cell spaces between 1989 and 1996. The inventory comprised one hundred and forty five ILW filter boxes and one hundred and sixty three 200-litre drums of PCM waste.

Localised shielding had been installed in various areas of the building to reduce background dose rates, in the form of concrete walls and lead sheets.

Due to the degraded nature of the primary containment of many of the drums and due to the discovery of free liquids within some of the drums, a dedicated containment facility was constructed to enable the wastes to be conditioned prior to dispatch to one of the site's PCM waste treatment facilities.

A campaign of rigorous waste characterisation enabled the filter boxes to be consigned as Low Level Waste instead of as Intermediate Level Waste in line with the principles of the waste hierarchy, with associated lifetime cost savings.

The disposal of these inter-cell waste packages led to a significant reduction in background radiation levels in the building, with levels decreasing from 850μSv/hr gamma to <2.5μSv/hr gamma.

PHASE 2 – CONSTRUCTION OF AN ENGINEERED STORE

Phase 2 of the project included three main activities; removal of the original building and associated structures; construction of a new waste store to provide controlled conditions in accordance with Site License requirements and the Ionising Radiation Regulations; and development of the scheme design for the waste retrieval phase.

Deactivation and demolition of original building

Following the removal of the inter-cell wastes from the building, preparation began for construction of a new building that would act as a suitable interim waste store and as a platform for the future recovery of wastes. The first step in this phase was the decontamination and dismantling of the old building structure and the associated pump house.

Dismantling of the contaminated brick-built pump house required the construction of a ventilated containment over the building in order to control levels of alpha contamination up to 160Bq/cm^2, with workers dressed in PVC suits and full-face respirators.

In preparation for the construction of the new building strip foundations and concrete slab for the future waste export facility, over 300m^3 of material was excavated and consigned as Very Low Level Waste to the on-site waste tip. Some of the excavated material was deemed fit for use as backfill for the future construction in order to minimise waste disposal and introduction of new materials.

The newly constructed concrete export slab also acted as a base for the operation of an 80-tonne crane for the deconstruction of the existing overbuilding and a 200-tonne crane for the construction of the new Storage & Retrieval Facility.

Construction of a new engineered store

Prior to commencing construction of the new store, it was necessary to carry out key enabling works due to the constrained nature of the site. The facility is located in the heart of Sellafield's Separation Area, surrounded on all sides by key operational facilities. The south gable end of the new building is situated less than one metre from one of the site's main effluent storage facilities.

In order to maintain access through the Separation Area it was necessary to construct a new road to ensure that Magnox reprocessing, waste management and other decommissioning projects could continue uninterrupted by the large-scale construction project. Additionally, the project was required to construct a temporary store for UO_3 drums to facilitate ongoing Magnox reprocessing operations.

A unique element of work, carried out for the first time in the Sellafield Separation Area, was the stabilisation of the ground surrounding the facility using a process of Soil Nailing. This was due to the potentially significant loads that could be imposed on the foundations during future waste retrieval operations, with consequential impact on adjacent nuclear facilities.

Figure 3 shows operators drilling 50mm diameter holes at approximately 2m centres, perpendicular to the 45^o batter. Steel bar 6-8m long was then inserted into the holes and fixed with grout. The batter was then covered in a surface layer of concrete and tensioned into the ground by bolting retaining plates over the steel bars. Although this is an industry standard technique, its use in the Separation Area required careful controls to ensure there was no spread of contamination from excavated spoil.

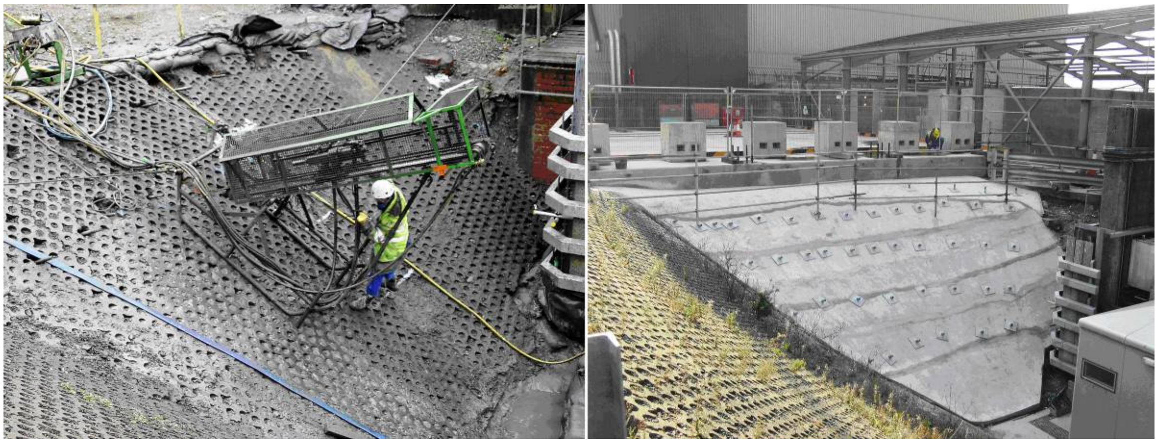

Fig. 3. Soil Nailing operations (left) and a section of completed batter (right)

A key feature of the engineering improvements to the storage arrangements for the cell wastes was the installation of new shielded covers on top of the 8 cells. This was to ensure full engineered containment of the cells and to reduce the radiation dose rates within the building. The additional and newly installed cell covers reduced contact dose rates on the cell tops from a peak of 620µSv/hr to 10µSv/hr, contributing to the significant reduction in ambient dose rates at the operations floor within this new building. Figure 4 shows operators installing the new ring beams to the top of the cells.

Fig. 4. Installation of ring beams to the top of the concrete cells as part of the improvements to the cell containment structure.

It can be seen from Figure 4 that the original cell covers were made up of a series of concrete planks. The degree of containment offered by these planks was limited and ingress of water into the cells was of concern, with significant degradation of the waste and potential transfer of activity to ground. Although temporary covers had been previously installed over the cell tops to offer some weather protection, the installation of modern water-tight covers was a major step forward in securing the condition of the waste and preventing radiological releases.

Construction of the new storage and retrieval facility building itself entailed over 2000 lifts utilising a 200-tonne mobile crane. The crane operations were restricted due to the constrained geography of the site and surrounding nuclear facilities and process lines. Despite this the main steelwork installation was flawlessly executed over a period of 8 months.

The ten year programme of work completed by Phases 1 and 2 of the project included waste disposal, decontamination and decommissioning of redundant facilities and the construction of a new storage and waste retrieval facility supported by a modern operational safety case. These actions coupled with a commitment to progress the retrieval of cell wastes by the year 2020 were sufficient to close out the regulatory License Specification to the satisfaction of the Nuclear Installations Inspectorate by the specified date of 1st August 2010 [2].

PHASE 3 – CHARACTERISATION & RETRIEVAL OF IN-CELL WASTES

Preliminary waste characterisation supporting the development of the project waste retrieval strategy was carried out as part of the Phase 2 scope of work. This enabled the new waste storage building constructed in Phase 2 to be designed with future waste retrieval operations in mind.

Initial characterisation and scheme design

Records of the cell inventories are incomplete, with documentary evidence supporting approximately 60% of the anticipated volume. No formal Conditions For Acceptance have been associated with the facility, but according to existing records the majority of the wastes were received from the following facilities:

- Magnox Separation Plant – 37% by volume
- Magnox Storage Ponds – 31% by volume
- High Active Liquor Evaporation & Storage Plant – 22% by volume
- Low Active Effluent Treatment Plant – 7% by volume

Additional materials are recorded as being consigned from several other facilities and anecdotal evidence suggests that the open-topped cells were also used in an ad-hoc manner.

Existing inventory data indicate that radiation levels at contact with waste items range up to 200mSv/hr gamma and based on the fingerprints of the four main consigning plants the predominant radionuclides expected to be present are Cs-137, Sr-90, Pu-241 and Ce-144. Waste items generally fall into the categories shown in Table I.

Table I. Approximate types of waste contained in the 8 cells.

Waste Type	Volume (m^3)
Filters	250
Drums	160
Miscellaneous Process Materials	60
Concrete	55
Miscellaneous Non-Process Materials	45
Flask	30
Total	600

On the basis of this historic information the project developed a strategy early in Phase 2 based on remote handling and consignment of the waste as ILW. A schematic of the scheme design solution is shown in Figure 5.

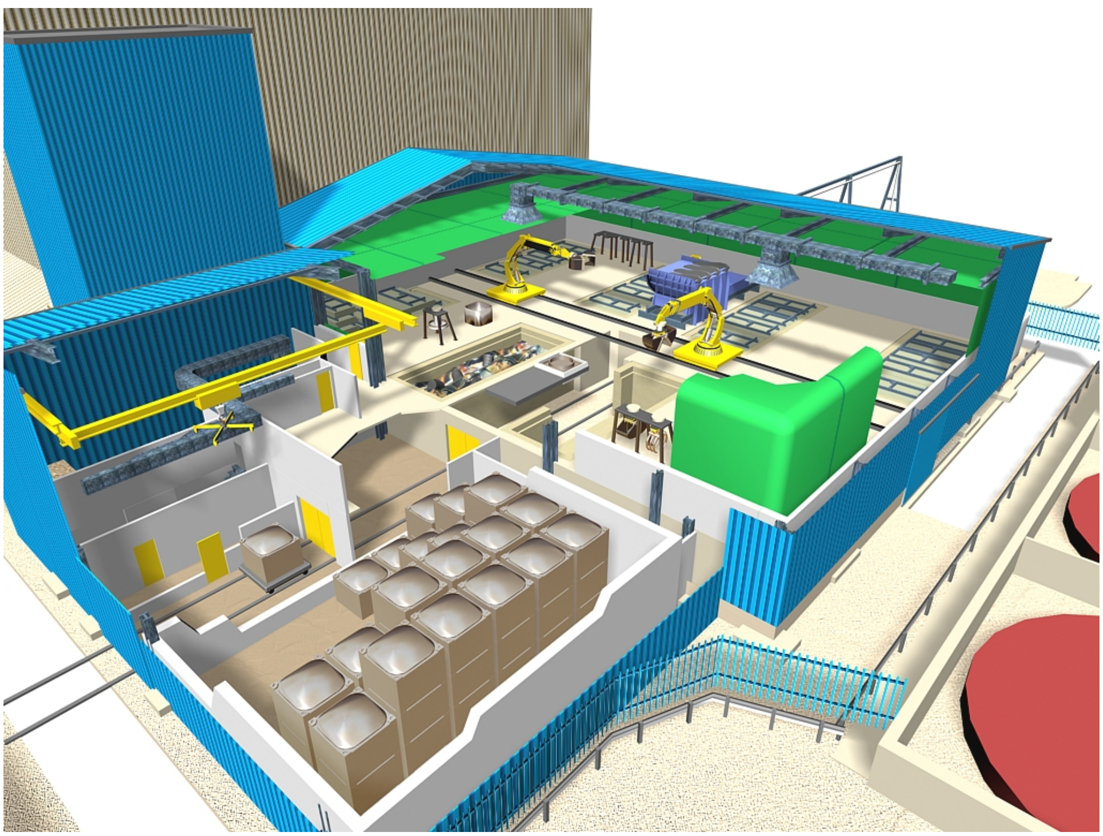

Fig. 5. Schematic of the original design solution for remote retrieval of waste from the cells and consignment as Intermediate Level Waste.

Revised Approach to Waste Retrieval

During the latter stages of Phase 2 it was possible to undertake some additional characterisation of the cells during the installation of the new containment covers. This work included photographic surveys of the cells and radiation mapping, revealing lower than anticipated levels of radiation, with a maximum of 4mSv/hr gamma dropping to 700μSv/hr gamma at 1m.

Cell 3 had the highest levels of radiation with an even distribution across the entire cell, whilst cells 2, 4 and 6 only had a small number of hotspots up to 2.5mSv/hr gamma (at contact) with levels generally an order of magnitude less. All other cells revealed generally lower levels of radiation up to 360μSv/hr gamma at contact.

Although some self-shielding will occur within the wastes, these recorded levels were much lower than expected based on the inventory records. Thus, a review of the project strategy was carried out to ensure that the approach was fit for purpose and would enable lower level wastes to be segregated from intermediate level wastes. It was considered that the lower activity levels would enable a more manual or semi-remote approach, instead of the fully remote scheme developed at the start of Phase 2. Thus, in March 2008 a Paper of Principle for the Waste Retrieval Strategy was endorsed in consultation with the nuclear regulators, identifying the following drivers for a change in the proposed strategy:

(i) Take advantage of opportunities to further minimise the volumes of waste consigned via each disposal route.
(ii) Eliminate / minimise the amount of re-work required to achieve a repository compliant package for ILW.
(iii) Ensure proportionate decisions are made regarding the equipment required in the operating cell, which will itself eventually require decommissioning and disposal.
(iv) Ensure compliance with emerging / improving Conditions for Acceptance of downstream plant.

It was considered that the design of the new overbuilding to be constructed in Phase 2 was largely applicable to the revised decommissioning approach since there may still be a requirement for some limited remote or semi-remote operations to deal with some of the higher-dose waste items.

Figure 6 outlines the revised approach, showing overlapping Characterisation and Waste Export packages constituting the Phase 3 scope of work. It is envisaged that segregation and recovery of low dose items may be possible on an opportunistic basis during the waste characterisation phase at the beginning of Phase 3.

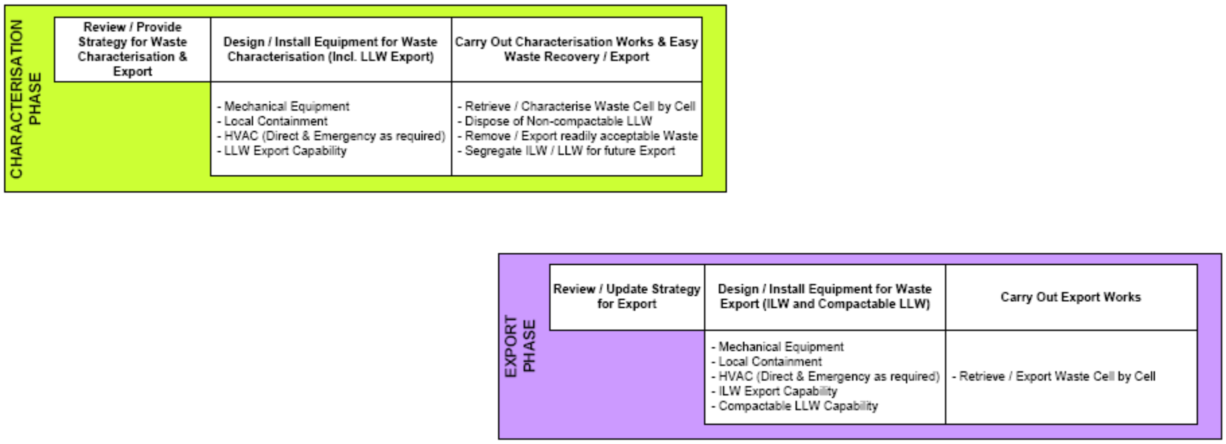

Fig. 6. Current strategy for detailed waste characterisation and waste export.

Another key element in progressing the project through Phase 2 was obtaining a Concept Letter of Compliance (LOC) from the NDA Radioactive Waste Management Directorate (RWMD), the body responsible for endorsing waste disposal arrangements for the UK's future Deep Geological Repository. A detailed investigation of the inventory records was coupled with design and engineering studies for waste treatment and disposal to form a robust submission to RWMD in 2007. A formal Concept Letter of Compliance was received from the Directorate in May 2008 [3].

The incomplete inventory records were used along with knowledge of the plants which were operational during the time the facility was being filled, to determine an envelope of likely waste types and radioactive contaminants within the cells. Design and engineering studies identified a number of options for the processing and packaging of the major waste categories (e.g. filter boxes, drummed waste, miscellaneous beta gamma waste). These were included within the LOC submission and the majority endorsed by RWMD, giving the project flexibility in planning waste retrieval operations within an overall strategy of segregating Low and Intermediate level wastes. This flexibility allowed Sellafield Ltd to demonstrate that viable waste routing options exist for a range of scenarios.

This enabled the project to progress on the basis of segregating wastes into Low and Intermediate Level Waste Streams with the conceptual use of a $3m^3$ box, with encapsulation using a Cementitious grout. Endorsement of the project's approach to waste characterisation and retrieval by this independent body also gave confidence to the Regulator that Sellafield Ltd had sufficient control of the stored wastes and supported the satisfactory closure of the License Instrument Specification.

Following on from the successful completion of Phase 2 of the project and closure of the Regulatory License Instrument Specification 324, the project has now commenced Phase 3. Characterisation work will continue until 2013, to be followed by a period of detailed design and installation of retrieval systems, culminating in the retrieval of the cell wastes by 2020.

CONCLUSION

A significant milestone was reached on 29th July 2010 at the NDA's Sellafield Site in the UK with the culmination of a 10 year programme of work to improve waste storage arrangements and to progress the decommissioning of one of the earliest legacy waste storage facilities on site. The project has overcome radiological challenges and difficult logistical constraints imposed by working in one of the most constrained operational areas of the Sellafield site.

Sellafield Ltd has implemented improved arrangements for the interim storage of Low and Intermediate Level Wastes within the 8 concrete cells, leading to satisfactory closure of License Instrument 324 issued by HM Nuclear Installations Inspectorate in line with the specified completion date of 1st August 2010.

Key learning from this project relates to the production of detailed designs for fully remote waste retrieval based on indicative waste characterisation information. The project should have progressed the characterisation and definition of the waste streams earlier in Phase 2 to avoid potentially unnecessary design works for a fully remote facility. However, the project did pause and review the approach and managed to reduce the complexity of the solution prior to entering the costly execution phase.

The endorsement of the Concept Letter of Compliance by the NDA Radioactive Waste Management Directorate was a key element of the revised approach to waste segregation and retrieval and also supported the closure of the License Instrument Specification by the Regulator.

Work to fully characterise the in-cell wastes and dispose of them via appropriate waste streams has commenced and is planned for completion by 2020.

REFERENCES

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