

INTEGRATED STRATEGIES FOR ACCELERATED REMEDIATION AT SELLAFIELD

N. Baldwin, J. Williamson

ABSTRACT

The BNFL Sellafield Site, in Cumbria, North West England, is one of the most complex, integrated and congested nuclear sites worldwide. In just two square miles it contains four times more radioactive inventory than all the US DOE sites in total. The Site has been in operation for over 50 years and has been associated with nuclear reprocessing throughout this time. As a result, there is a significant inventory of legacy wastes, currently stored safely, to be retrieved and put into passive storage. This is a key early step in progressing remediation of the site. The first Lifecycle Baseline for Sellafield, produced in mid 2003 to the requirements of the new Nuclear Decommissioning Authority, shows the full cleanup and restoration of the site continuing until 2150.

The focus of BNFL at Sellafield is now changing from continued commercial reprocessing to clean up of the site and the Site Remediation Team has been set the task of developing integrated strategies, new thinking, new approaches and overall acceleration to achieve much earlier hazard reduction and an overall improvement to the clean up programme. Figure 1 illustrates one of the many current clean-up operations at Sellafield. The paper addresses the outcome of the strategic review of BNFL to bring about the change of focus and the results of the work to produce the first Remediation Strategy for Sellafield to achieve accelerated clean up.

The paper will be of interest to those involved in developing accelerated clean-up plans for nuclear sites and those who can be involved in implementing Sellafield Clean-up.



Fig, 1. Retrieval & Remediation Operations at Sellafield.

INTRODUCTION

Sellafield is the largest and most complex nuclear site in the UK and one of the most concentrated integrated sites worldwide. More than 1000 buildings including over 200 active facilities operating together on a 2 square mile site on the North West coast of the UK on the outskirts of the English Lake District.

Whilst initially part of the UK military weapons programme, the site has evolved to become a fully commercial operation with two full scale reprocessing plants and more than 50,000te of Magnox and Oxide fuel successfully reprocessed over the past 50 years. Figure 2 is a 1960's photograph of the developing reprocessing complex.

While reprocessing continues to meet remaining customer requirements, the overall focus at Sellafield is switching to clean-up and remediation of the nuclear legacy which has arisen over the past 5 decades.

During WM'03 the paper “Remediating Sellafield – A New Focus for the Site” (Ref 1) was presented and addressed how the scale of the clean-up challenge was being met and how a new strategy was being development by the Site Remediation Team within BNFL.

This paper describes how the Remediation Strategy for Sellafield is being developed including a series of **Integrated Strategies** to ensure earlier hazard reduction encompassing new thinking, new approaches, innovation and acceleration of the clean-up mission for the site.



Fig. 2. “The legacy of wastes and buildings to be remediated at Sellafield has accumulated over 5 decades, dating back to the start of the UK Military Nuclear Programme”

SELLAFIELD LIABILITIES IN A UK CONTEXT

In November 2001 the UK Government announced the setting up of a Nuclear Decommissioning Authority (NDA) and the Liabilities Management Unit (LMU) of the DTi was formed to pave the way for the new authority. The Government White Paper “Managing the Nuclear Legacy – a strategy for action” (Ref 2) was published in July 2002 followed by a Draft Energy Bill in November 2003 (Ref 3). The Energy Bill is now passing through parliament with the objective of establishing the NDA to manage the UK nuclear assets and liabilities from April 2005.

The total future clean-up business in the UK has been evaluated at £48 billion (or some US \$75 billion). Of this, approximately 56% £27.5 billion is associated with the remediation of the Sellafield Site.

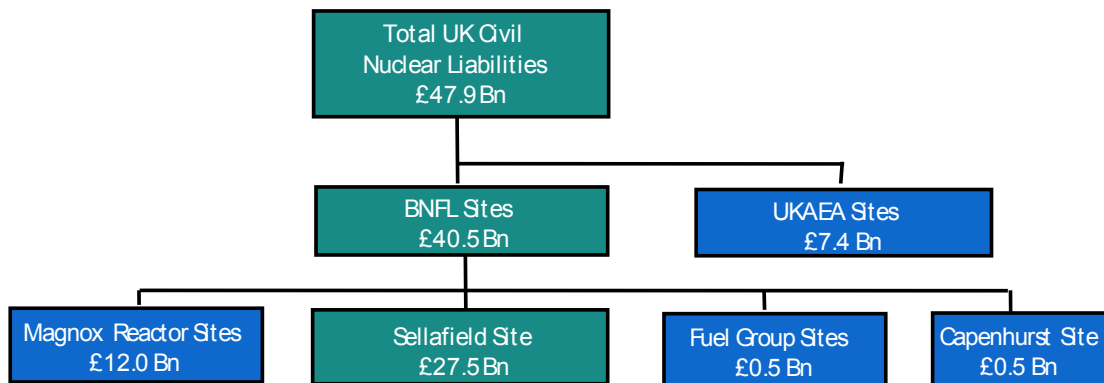


Fig. 3 “Sellafield represents almost 60% of future UK civil nuclear liabilities”

The future NDA will use Lifecycle Baselines LCBL’s to assess the lifetime liabilities for each of its 22 UK sites. Initial baselines for each site were produced during 2003 prompted by the LMU. LCBL’s for Sellafield and the nearby Drigg Low Level Waste Disposal Site were produced by the Site Remediation Team. These were completed ahead of schedule, encompassing full future workscope and within the production budget. The LCBL for Sellafield included the £27.5bn described in Figure 3 above. The Sellafield LCBL indicated substantial spend continuing until 2120 and beyond with institutional control after 2150.

BNFL STRATEGY REVIEW

On 3 July 2003, the Secretary of State announced that the Government and BNFL had agreed to conduct a joint review of BNFL’s future strategy. The announcement of the review took account of the significant developments in BNFL’s key businesses, the nuclear industry and in the Government’s efforts to encourage a competitive clean-up market in the UK since 2001, and followed the Government’s decision that a flotation of the company after the Nuclear Decommissioning Authority (NDA) has been formed should no longer be an option.

The outcome of the joint review was announced in mid December 2003 and the main conclusions were:

- A new parent company will be established in April 2005 to hold those parts of BNFL that will not become the NDA's responsibility.
- Following the creation of the NDA, the principal focus of the successor company will be the clean-up at UK sites.
- Concurrently with the new parent company being established, a new group of subsidiary companies will be set up with initial responsibility for managing clean-up operations at sites under arrangements to be agreed by the NDA.
- The vast majority of the existing BNFL UK workforce will remain employed by companies that operate current BNFL sites – other employees will transfer into companies within the clean-up group.
- A new Nuclear Science and Technology Company (NSTS) will be formed as a subsidiary, and will provide research and technology services on a commercial basis.
- Other businesses will be managed to deliver value and in a way that limits and controls risk to the UK taxpayer.
- Steps will be taken to allow the Westinghouse business to operate with greater financial independence from its parent and open up possibilities for private sector participation.

The detailed organisational arrangements which flow from the review findings are being finalised. The review paves the way for a clear focus on clean-up at Sellafield.

DRIVERS FOR CHANGE AND CHALLENGES

The Sellafield site has been a safe and secure location for storage and reprocessing of spent fuel for more than 50 years. It is important to recognise that, in partnership with its supply chain contractors, BNFL has carried out significant remediation over recent years, including, for example:

- Treatment and Encapsulation of all new arisings of Intermediate Waste at Source (>26,000 drums)
- 500m³ of waste solvent treated
- 11,000m³ of medium active liquors recovered and processed
- A substantial programme of decommissioning projects completed
- More than 2,500 containers of vitrified Highly Active Product (1 billion curies of radioactivity). See Fig. 4.

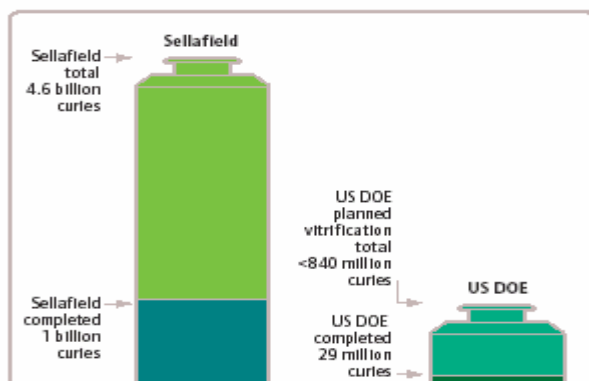


Fig. 4. “The scale of the remediation challenge at Sellafield is significant. The quantity of radioactivity in high level liquid waste to be vitrified is significantly greater than that planned to be vitrified in the US DOE complex”.

BNFL has had long term plans for discharge of the liabilities at Sellafield for some time. However, over recent years a number of challenges have crystallised which made it clear that a new approach was needed. Traditional approaches result in unacceptably long remediation timescales and so more radical options have been sought. The key challenges can be summarised as:

- **BNFL Board Challenge** – to provide safer, sooner and cheaper options for the remediation of liabilities at Sellafield.
- **NII Challenge** – to provide decommissioning plans which align with the Improvement Notices and Specifications imposed by the NII.
- **EA Challenge** – to reduce the risk to the environment.
- **LMU/NDA Challenge** – to provide, through innovation, improvements in the LCBL and, as a minimum, to align it with the requirements of the regulators.
- **UKAEA/MOD Customer Challenge** - provide enhanced value for money, delivering capability, affordability and customer involvement.

LEGACY PONDS & SILOS STRATEGY

A vital component of the clean-up challenge for Sellafield is dealing with the Legacy Ponds & Silos as illustrated in Figure 5. These facilities are a substantial proportion of the future liabilities and are a key focus area for BNFL, Regulators, Current UKAEA/MOD customers and for the NDA. Substantial investment has been undertaken to develop an accelerated strategy to deal with these facilities which date back to the 1940’s and 50’s and contain legacy waste. In summary the waste includes:

Solid Intermediate Level Wastes

3,500m³ of intermediate solid waste consisting of mainly aluminium and magnox fuel cladding, swarf and graphite but also miscellaneous other wastes is stored in dry silos. This is basically a grain silo design and comprises a six compartment above ground structure. Whilst in general the waste has remained in good condition due to the potential fire risk from degradation of some of the waste an argon purging regime has recently been successfully commissioned and brought into service.

9,700m³ of mainly magnox fuel cladding swarf but also other miscellaneous solid intermediate level waste is stored in water filled silos. This facility was initially of six compartments but three extensions increased the number to 22 and also progressively improved the build standard. The condition of the waste varies between the compartments. Corrosion of the Magnox fuel cladding was encouraged in the earlier compartments by the addition of sodium chloride whilst in later compartments cooling and caustic dosing of the water has sought to reduce the rate of corrosion. The potential for hydrogen generation has resulted in the installation of a high capacity emergency nitrogen purge system. Whilst the inventory of the waste is broadly known its condition varies and sampling can only be indicative.

Pond Wastes

1,100m³ of sludge, mainly from corroded fuel, and about 320te of fuel debris remains in the first two operational ponds together with the pond furniture. The pond is subject to a substantial purge to control the activity levels but it is impossible to fully arrest the corrosion process.

Liquid Wastes

Pond and silos liquors contain dissolved fission products and corrosion products, substantial values of essentially Intermediate Level liquor requires management and will be treated and recorded.



Fig. 5 “Legacy ponds & silos containing intermediate level solid, liquid and corrosion product sludges”

The Site Remediation Teams’ prime focus has initially been on the Legacy Ponds & Silos (LP&S) which contains the bulk of the Sellafield Intermediate Level Waste. These plants currently represent some of the greatest potential hazards on site and one of the most difficult clean-up challenges worldwide. See Fig. 6.

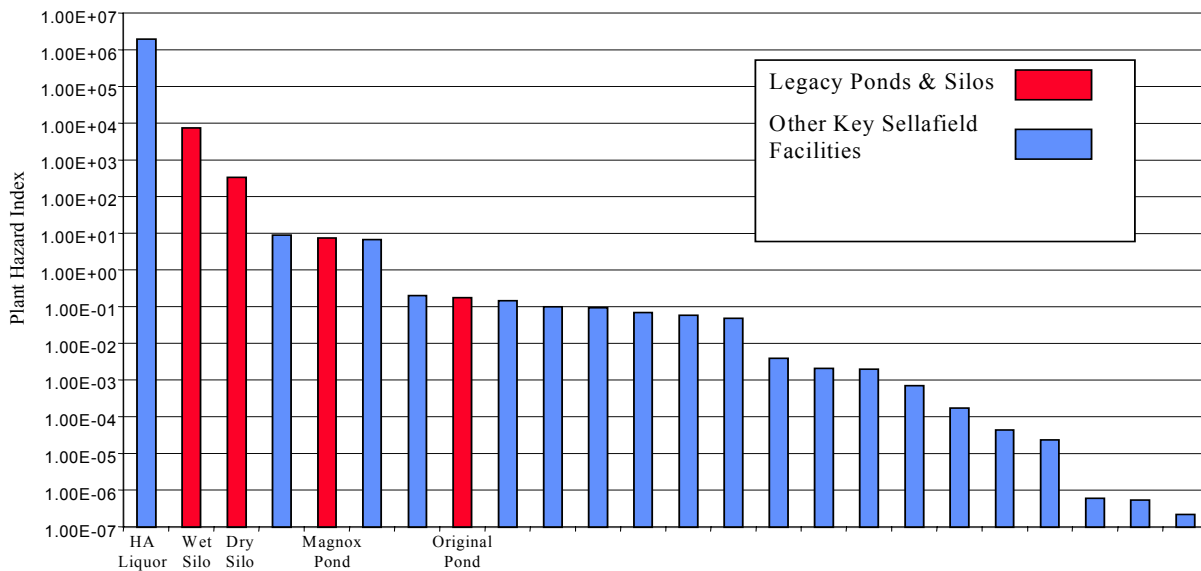


Fig. 6 “The Sellafield clean-up challenge and significance of legacy ponds & silos”

ACCELERATION OF LEGACY PONDS & SILOS CLEAN-UP

In November 2001 the strategy for remediation of Legacy Ponds & Silos (LP&S) estimated that bulk retrieval of material would not commence until 2011 and would take of the order of 25 years to complete.

By subjecting the programme to a process of progressive challenge; by looking at innovative ways of dealing with the issues that constrain progress; and by establishing the guiding principles set out below, the potential has emerged of bringing forward the start of bulk retrievals from these historic plants by about 4 years and substantially shortening the length of the programme to achieve completion by around 2020 (ie 15 years earlier).

The guiding principles adopted as part of the strategy review and formation of what is known as the LP&S Early Retrieval Project.

Guiding Principles:

- *Early hazard reduction as the primary driver*
- *The adoption of a more pragmatic approach to safety cases and methods of working*
- *Flowsheet and process simplification*
- *Alternative waste packaging including non-cemented waste forms (Interim Safe Storage)*
- *Maximum use of existing assets and more radical design of new treatment plants*

The LP&S Early Retrievals Project has now progressed to the point where the basic strategy review and reformulation is complete and an implementation plan can be developed. Moving into implementation and delivery is a massive challenge for BNFL, for our supply chain partners and for the future NDA. The revised strategy results in the opportunity to meet regulator legal specifications and to bring about early hazard reduction, additional funds and resources are likely to be needed in the short to medium term. Reprioritisation and release of funding will be a challenge.

BENEFITS FROM INTEGRATION OF SELLAFIELD STRATEGIES

Part of the role of Site Remediation is to identify those strategies which need implementation to support early hazard reduction and environmental improvement. Several “Enabling Strategies” have been identified which must be revised, updated and implemented to support Legacy Ponds & Silos. These include:

- Overall Site Storage Strategy
- Overall Site Effluent Strategy
- Site Infrastructure

As part of the Remediation Strategy for Sellafield Strategies are integrated which are either directly associated with Remediation and Hazard Reduction at Sellafield or are new approaches emerging from the strategy review:

Key Activities associated with Passivation/Hazard Reduction at Sellafield

Established strategies

- Completion of the Magnox reprocessing programmes
- Vitrification of HA liquor stocks
- Conversion of all PCM to ISS
- Return of Vitrified HLW to overseas customers
- Ongoing provision of an appropriate infrastructure, including effluent management
- Work off of historic MA liquor stocks



Fig. 7 “Vitrified product containers”

New Approaches emerging from this Remediation Strategy for Sellafield include:

- Emptying of the Legacy Ponds & Silos and the conversion of all associated waste to ISS
- Conversion of Sixep sludge and filter bed materials to ISS
- Resolution of orphan wastes
- Accelerated deactivation of facilities as they become redundant
- Removal of redundant pond furniture

Completion of the above strategies and implementation in an integrated manner creates potential major benefits and the opportunity for early passivation of the Sellafield Site. Figure 7 illustrates the container design used to contain Vitrified High Active Waste (Vitrified Product Containers).

POTENTIAL PASSIVATION BY 2020

The successful implementation of the Legacy Ponds & Silos Early Retrievals Project when set alongside other site clean-up strategies and projects such as vitrification of HA liquid wastes creates the opportunity to move the site to a passive state by around 2020, some 20 years sooner than present plans.

“Passivation” is the concept whereby the majority of the sites waste is immobilised, packaged in modern containment and held in modern, monitorable stores from which it can be returned in the future. This is the **Interim Safe Storage (ISS)** concept which BNFL has developed and pioneered. The concept of ISS and passivation by 2020 provides the capability for storage of waste forms for around 100 years. This acknowledges the issue that national waste disposal routes are unlikely to be available in the UK, for many decades.

Although some buildings and facilities will remain on the site the major hazard will be reduced by several orders of magnitude once wastes are treated and placed in Interim Safe Storage. The site will be significantly easier to manage and at lower cost.

OPPORTUNITIES FOR FUTURE ACCELERATION

Implementation of the integrated strategies described above can produce a passivated Sellafield Site by around 2020. However this then requires substantial, if reduced Care & Maintenance, Surveillance of stores, maintenance of infrastructure and institutional control.

Once the site is passivated with hazard and environmental risk reduced there is the opportunity to take strategic choices on further acceleration. These include:

- **Extended Interim Safe Storage with Early Decommissioning**
This option includes a consolidation phase where remaining operations, chiefly storage, and rationalised and redundant buildings are decommissioned to a suitable hold point consistent with the concept of ISS. This provides the opportunity to reduce the number of facilities on site but brings forward spend in the short and medium term.
- **Radical Acceleration**
Radical acceleration with relatively early site closure can only be achieved once decisions are taken on issues such as UK waste disposal sites, product disposition, site end points.

This second strategic option is more radical would require that waste routes and a final storage or disposal site becomes available in the UK and that a clear position can be agreed with the NDA on the site end state.

REMEDIATION STRATEGY AND THE NEAR TERM WORK PLAN

As formation of the NDA approaches in April 2005 all UK nuclear liabilities sites including Sellafield are producing detailed initial Near Term Work Plans to cover the periods 2004/05 and 2005/06 financial years for submission to the LMU by April 2004. Any necessary modifications to the LCBL or NTWP in order to implement the revised strategies are being introduced via change control and, in future the Remediation Strategy for Sellafield will be part of the ongoing LCBL process.

CONCLUSIONS

Clean-up of the Sellafield Site is a massive and challenging task. A strategic approach has been applied in order to meet multiple challenges. Substantial progress has been made over the past 18 months developing an improved and accelerated strategy for Legacy Ponds & Silos. A “Remediation Strategy for Sellafield” has been developed by the Site Remediation Team.

Implementation of the strategy is now being planned. This is a massive and challenging task and will require an integrated approach and support from Regulators, NDA and the supply chain.

REFERENCES

- 1 “Remediating Sellafield – A New Focus for the Site”. Waste Management, February 2003
Tucson Arizona – N D Baldwin, British Nuclear Fuels plc
- 2 “Managing the Nuclear Legacy – A Strategy for Action”. UK Government White Paper,
July 2002. Department of Trade & Industry, UK
- 3 “Draft Energy Bill”, November 2003, Department of Trade & Industry, UK