

**cavendishTM
nuclear**
part of Babcock International Group

cavendishnuclear.com

Decommissioning and Waste Management

Creating a safe and secure world together

Cavendish Nuclear has over 60 years' experience of decommissioning and waste management.

Our experience is drawn from a heritage of being the licensee of the Harwell, Winfrith, Magnox, Dounreay and Windscale nuclear sites. This includes a total of 27 different reactors ranging from small scale piles at Harwell to highly complex power generating reactors such as the Steam Generating Heavy Water Reactor (SGHWR) at Winfrith, the Prototype Fast Reactor (PFR) at Dounreay and the Windscale Advanced Gas Cooled Reactor (WAGR). This experience has also been applied to complex nuclear reactor decommissioning programs across Europe and beyond.

With approximately 100 specialists in waste management and characterisation, and decades of experience, Cavendish Nuclear has strength and depth in the vital phases of strategy development, planning and characterisation. In addition, we also have over 1000 mixed discipline engineers, project managers and safety case specialists capable of realising waste projects from concept through to manufacture, installation, and commissioning.



At a Glance



Access to 5,000 nuclear SQEP personnel



Strategic partner supporting nuclear companies in the lifetime extensions of their fleet

60+

years of industry heritage



Supporting delivery of the UK's first new nuclear power station in a generation



Experienced operator of nuclear sites



Delivery of large-scale engineering projects across the UK nuclear estate



Cavendish Nuclear proposes solutions that minimise complexity and make maximum use of commercially available equipment. Our skill lies in how we integrate these together to provide cost effective, timely and robust solutions, while our tier 1 and tier 2 experience gives us direct operational knowledge and insight into customer constraints and priorities when developing solutions and managing risk.

Key Capabilities and solutions:

Strategy & planning

- Waste strategy development
- Horizon scanning, technology development and innovation
- Feasibility and options studies
- Technical evaluations
- Engineering design
- Information management
- Nuclear Safety and environmental impact analyses

Waste characterisation

- Characterisation planning
- Alpha, beta and gamma in-situ non-destructive assay
- Plutonium Hold-Up Measurement System (PHUMS)
- Customised system design and operator interface controls and visualisation
- In storage monitoring of waste packages
- Accredited low activity laboratory services – sample preparation, analysis and interpretation of hazardous chemicals and low activity materials

Retrievals and processing

- Legacy waste retrievals and processing engineering design, build and commissioning services
- Integrated assay and operator software
- Facility decommissioning waste handling and processing engineering design and build

Operator training

- Test facility and workshops
- Storage and disposal
- Facility design
- Customised design and manufacture of shield doors
- Design and installation of ME&I infrastructure including control systems

Backed by innovation and technology:

Cavendish Nuclear is part of the Babcock innovations group, which draws on a wide range of sources to provide a breadth and depth of technical insight pulling together technologies from different sectors.

We are also members of various forums, including the Advanced Nuclear Research Centre (ANRC) and the Nuclear Advanced Manufacturing Research Centre (NAMRC).

Digital solutions

The creation of our digital solutions has helped improve efficiency and provide innovative solutions to the UK's Nuclear challenges, across all areas – from the initial project set up to project completion.

Our solutions have helped the industry to effectively plan and efficiently resource its ever-growing demand.

Particle Swarm Imaging (PSIM) - Developed by Cavendish Nuclear, PSIM provides an assay solution for specialist measurements of waste items, from small packages to large ISO-freight containers, and plant infrastructure.

AmCam - AmCam is a handheld, compact, lightweight device that combines a gamma ray spectrometry detector with a small video camera, capable of indicating radiation count rate alongside a corresponding video image of the area being surveyed.

Images - IMAGES provides an innovative management solution for site characterisation, decommissioning, environmental monitoring, and land quality data.

Geographical Information Systems (GIS) - Cavendish nuclear have 15 years of experience using GIS across nuclear sites for multiple clients.

In cell Decommissioning (IDS) - Our IDS system is a remote deployed device that has increased the capability and speed with which redundant active reprocessing cells can be decommissioned.

Plutonium Hold-Up Measurement System (Phums) - Our fast neutron detector based Phums is a lightweight, compact, and portable assay system with the flexibility to measure the nuclear material of a wide range of objects.

Programme Management Reporting System (PMRS) - PMRS is an integrated project controls system that provides a suite of Baseline Management and Earned Value (EV) reports.

Case study 1

Waste Retrievals and Processing

Berkeley Waste Vaults, Magnox Ltd

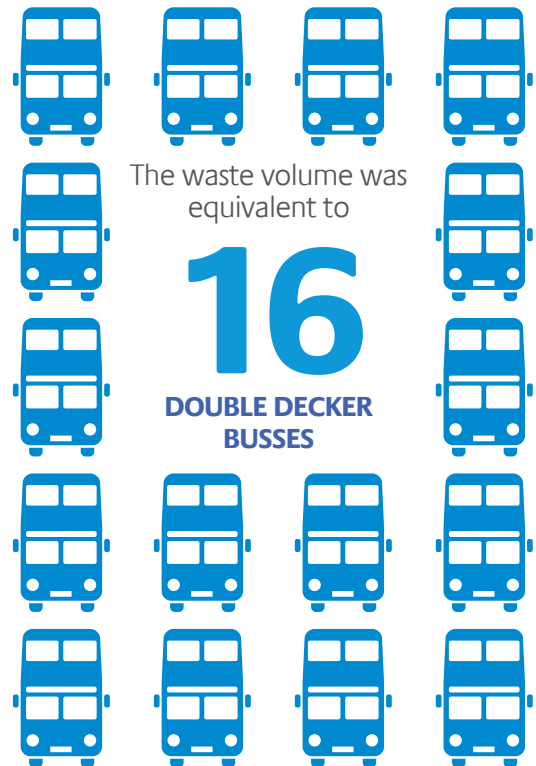
The challenge was to recover several hundred tonnes of uncharacterised waste from three legacy underground vaults and provide the operator with enough real-time information to compliantly package the waste within set limits and with minimal disruption to the waste handling processing operations.

The requirement was to remotely extract the waste and process into suitable RWM compliant waste packages for future disposal. The design, build and install project was broken into 3 discreet projects (waste routes):

R2 - Retrieval equipment to recover waste from all vaults and facility to process the Fuel Element Debris (FED) into compliant ILW disposal packages

R3 - Facility to process containers and load into compliant packages

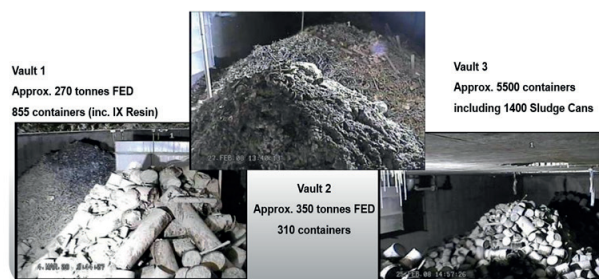
R4 - Retrieval and process facility for the sludge cans.



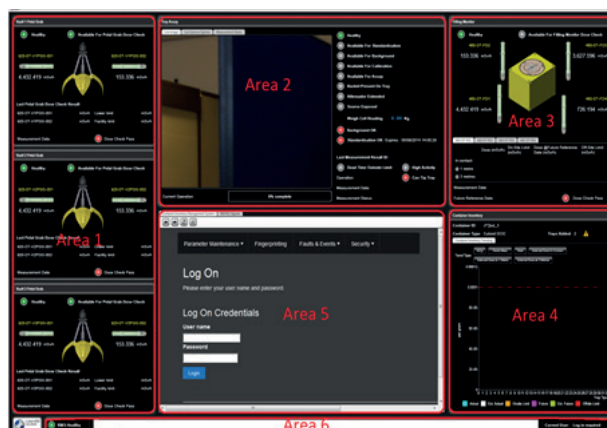
The waste processing facility was made up of several modules, each with a defined function, had over 70 shielding plates and had to be compliant with building codes, as it was external to the facility.

Customised software was developed to provide a real-time visual display of data to inform operator go/ no go decisions for filling containers to ensure disposal and transport compliance. The system enabled the operator to perform grab dose checks, sort tray assay, container fill dose checks, container inventory checks, and automatically store all associated records (including photos, spectra, fingerprints used, logs, reports). The complete facility was assembled off-site and fully tested with the operators who were to carry out all tasks, before being stripped down and sent to site for installation.

The outcome from this approach has been the successful commencement of retrieval operations in 2016 by the Magnox team. The overall project duration for all three processing routes was 10 years at an outturn of over \$100M. Approximately 40% of the overall contract value was delivered by Cavendish Nuclear's supply chain partners.



Waste tipping and package loading modules at works testing site.



Real time display.



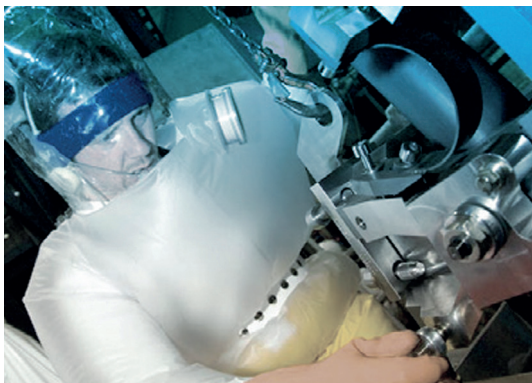
Case study 2

Decommissioning and Waste Management Projects in which Cavendish Nuclear was the Prime or a main delivery contractor.

- WAGR Core dismantling Berkeley
- Hunterston Solid Active Waste Bunker Retrieval and ILW Store
- Trawsnydd Ponds Decontamination
- Trawsfydd ILW Store
- Wylfa used damaged fuel recovery and storage
- Sellafield Pile Fuel Storage Ponds Retrieval
- Sellafield Bunkers Retrieval and Encapsulation
- Sellafield Fuel Reprocessing Waste Silo
- Maintenance Facility
- Sellafield Reactor Fuel Cladding Silo Retrieval Project
- Sellafield Waste Encapsulation Product Store and
- Comprehensive Import Export Facility

International decommissioning projects in which Cavendish Nuclear played a key role.

- Ignalina, Lithuania: specification of decommissioning strategy and detailed delivery design for Russian RBMK reactor
- Kozloduy, Bulgaria: specification of decommissioning strategy and delivery model
- Metsamor, Armenia: develop the Initial Decommissioning Plan and radioactive waste management strategy
- Bohunice, Slovakia: Design for Decontamination and Dismantling of Russian VVER Reactors





**cavendish
nuclear**
part of Babcock International Group

Planning and Management Projects.

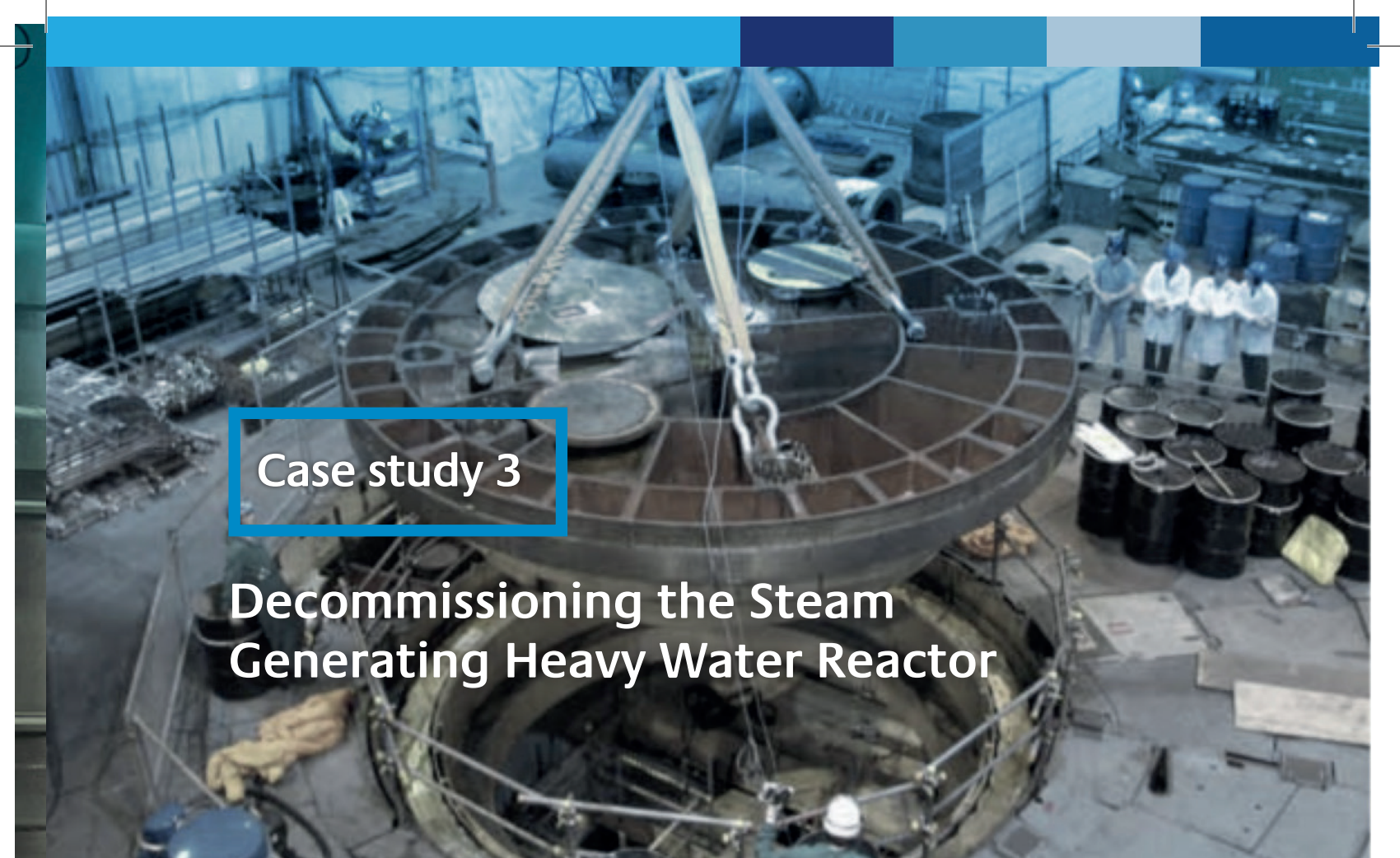
- SOGIN (Italy): development of baseline decommissioning plan for 3 sites in Italy
- EDF CIDEN (France): dismantling planning for Bugey, St Laurent and Chinon Graphite plants
- Tokai (Japan) Reactor Decommissioning Planning and detailed specification
- Tokai (Japan) ILW Bunker Waste Recovery Planning and detailed specification

- JRC Ispra (Italy)
– Contaminated Sodium disposition
- National Disposal Facility for LLW, Bulgaria – to lead the development of technical design, site selection, environmental impact assessment and safety justification
- Non – Proliferation programme, Russia, programme managers for physical protection and security upgrades, security training and sustainability planning

Spent Fuel Storage Projects in which Cavendish Nuclear was the Prime or a main design / delivery contractor.

- Wylfa Dry Store Cells 1-3 (Wales, UK)
- Wylfa Dry Store Cells 4-5 (Wales, UK)
- Fort St Vrain Modular Vault Dry Store (Colorado, USA)
- Paks Modular Vault Dry Store (Hungary)
- Idaho Spent Fuel project (Idaho, USA)





Case study 3

Decommissioning the Steam Generating Heavy Water Reactor

The 100MW Steam Generating Heavy Water Reactor (SGHWR) was the largest and most complex decommissioning task at the former UKAEA research site at Winfrith in Dorset.

- The reactor, which operated from 1967 until 1990, is similar in design to CANDU reactors. Light water was pumped over the fuel elements, boiled and the steam passed directly to the turbine. The absence of heat exchangers meant the turbines and cooling system as well as the reactor became contaminated. Heavy water controlled the reactivity in the Calandria.
- Following initial fuel element removal and decommissioning of the reactor by Cavendish Nuclear's subsidiary, the Nuclear Decommissioning Authority turned to Cavendish Nuclear in 2011 for a strategy to complete its decommissioning. The rate at which SGHWR could be dismantled determined the date for remediation of the whole site; thereby it was on critical path.

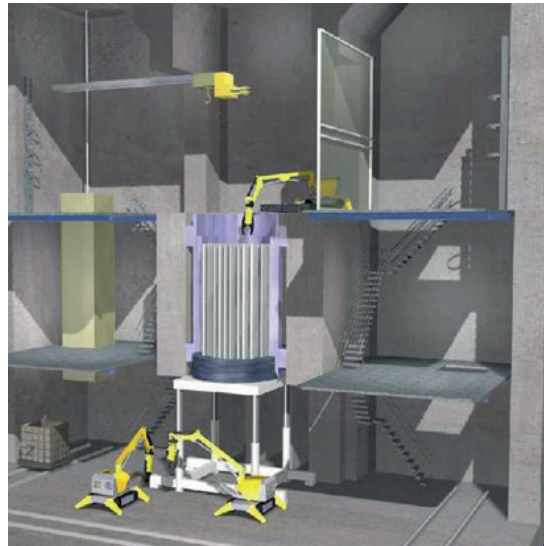
Cavendish Nuclear's strength in depth and broad experience allowed us to put together a team of specialists capable of giving the customer the optimal solution, using a number of criteria – simplicity, minimal new construction, minimal dependencies, use proven technology, has high confidence levels and is consistent with regulatory requirements and site end-state criteria.

Our programme of work to deliver this included development of technical and waste management methodologies, underpinning schedule and cost data, and associated stakeholder and implementation management plans.

The Steam Generating Heavy Water Reactor was defueled in 1991 and its D2O coolant removed. In 1997, it was placed in care and maintenance.

In 2005, Cavendish Nuclear developed a two-phase strategy to perform decommissioning:

- Remove secondary containment and decontaminate to low levels (completed in 2007).
- Remotely remove core and package as ILW, remove primary containment, decontaminate all areas, demolish all structures, and restore site.



This work was accelerated to achieve an end date for the site in 2021 and includes:

- Remove Primary Containment
- Design, build, commission, operate and decommission new plant:
 - Core Segmentation
 - ILW Processing
- Remove all other equipment and materials
- Decontamination to meet release criteria
- Demolition and Site Restoration
- Maintenance of assets pending disposal

The existing reactor building structure is being modified to create a number of new compartments;

- Segmentation Cell
- Core Jacking Area
- ILW Processing Plant / Grouting Plant
- Decontamination Cell
- Service Cell
- Central Control Room

The main compartment is the Segmentation Cell, where the core was cut up using two remotely-operated demolition machines and four hydraulic lifting arms which segment the core from outside-in.

Intermediate level waste was encapsulated with grout and stored in a 6m³ ILW box, with a total weight once conditioned of 50 tonnes. Approximately 75 waste boxes were produced.

An area of the primary containment was cleared and adapted to accommodate a reactor core jacking mechanism which raised the core incrementally into the Segmentation Cell.

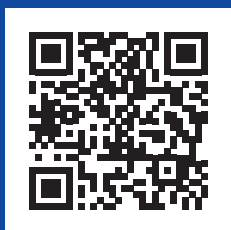
The objective was to clean structures to an underground depth of 1m and backfill with recycled concrete and masonry from the decommissioning.

Total waste generated- 410 tons of ILW, 4,200 tons of LLW and 9,200 tons of clean, excluded or free release waste.





To find out more about Cavendish Nuclear's decommissioning and waste management services please scan the QR code below:



Or alternatively please contact:

Junichi Hikosaka
Cavendish Nuclear Japan KK

+81 90 8434 6119
Junichi.Hikosaka@cavendishnuclear.com

Arca Central Building, 14/F, 1-2-1 Kinshi, Sumida-ku,
Tokyo, 130-0013, Japan

Or:

Chris Carter
Cavendish Nuclear Limited

+44 779 633 7261
chris.carter@cavendishnuclear.com

20 Radar Road, Leicester, LE3 1UF United Kingdom

www.cavendishnuclear.com