

<b>WASTE STREAM</b>	<b>5C302</b>	<b>BEPO Reactor Decommissioning ILW</b>
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**SITE** Harwell  
**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** ILW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2022.....	0 m <sup>3</sup>
Future arisings -	1.4.2025 - 31.3.2037.....	561.0 m <sup>3</sup>
Total future arisings:		561.0 m <sup>3</sup>
Total waste volume:		561.0 m <sup>3</sup>

Comment on volumes: Volume updated for 2016 RWI to reflect SMART Inventory Review

Uncertainty factors on volumes: Stock (upper): x Arisings (upper) x 1.2  
 Stock (lower): x Arisings (lower) x 0.8

**WASTE SOURCE** Reactor decommissioning of 6.5 MW(T) reactor with graphite moderator and air cooling.

**PHYSICAL CHARACTERISTICS**

General description: Graphite bricks (740 x 185 x 185mm) moderator, and reflector, some of which have been in contact with the fuel elements. Mild steel plate 5/8" thick.  
 Physical components (%wt): Graphite blocks, moderator and reflector (9.6%) and steel plates (0.4%). Small amounts of stainless steel and boron carbide. Trace amounts of aluminium and potentially bismuth.  
 Sealed sources: The waste does not contain sealed sources.  
 Bulk density (t/m<sup>3</sup>): 2.3  
 Comment on density: This is based on the theoretical densities of: Graphite = 1.64 t/m<sup>3</sup>; Steel = 7.9 t/m<sup>3</sup>.

**CHEMICAL COMPOSITION**

General description and components (%wt): Graphite (98%) and steel (2%).  
 Chemical state: Neutral  
 Chemical form of radionuclides: H-3: Present in graphite.  
 C-14: Present in graphite.  
 Cl-36: Present from the activation of trace impurities in the graphite.  
 Metals and alloys (%wt): The mild steel plates are 5/8" thick.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	TR		
Other ferrous metals.....	2.0	Mild steel	
Iron.....			
Aluminium.....	TR		
Beryllium.....	0		
Cobalt.....			
Copper.....	0		
Lead.....	0		
Magnox/Magnesium.....	0		
Nickel.....			
Titanium.....			
Uranium.....	0		

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Zinc..... 0  
 Zircaloy/Zirconium..... 0  
 Other metals..... TR

The thermal column may contain small amounts of cadmium and bismuth.

Organics (%wt): No organics are present.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulose.....	0		
Paper, cotton.....	0		
Wood.....	0		
Halogenated plastics .....	0		
Total non-halogenated plastics.....	0		
Condensation polymers.....	0		
Others.....	0		
Organic ion exchange materials....	0		
Total rubber.....	0		
Halogenated rubber .....	0		
Non-halogenated rubber.....	0		
Hydrocarbons.....			
Oil or grease .....			
Fuel.....			
Asphalt/Tarmac (cont.coal tar)...			
Asphalt/Tarmac (no coal tar)....			
Bitumen.....			
Others.....			
Other organics.....	0		

Other materials (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	0		
Inorganic sludges and flocs.....	0		
Soil.....	0		
Brick/Stone/Rubble.....	0		
Cementitious material.....	0		
Sand.....			
Glass/Ceramics.....	0		
Graphite.....	98.0		
Desiccants/Catalysts.....			
Asbestos.....	0		
Non/low friable.....			
Moderately friable.....			
Highly friable.....			
Free aqueous liquids.....	0		

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Free non-aqueous liquids..... 0

Powder/Ash..... 0

Inorganic anions (%wt):        None present.

	(%wt)	Type(s) and comment
Fluoride.....	0	
Chloride.....	0	
Iodide.....	0	
Cyanide.....	0	
Carbonate.....	0	
Nitrate.....	0	
Nitrite.....	0	
Phosphate.....	0	
Sulphate.....	0	
Sulphide.....	0	

Materials of interest for waste acceptance criteria:        There is a possibility of stored Wigner energy in the graphite.

	(%wt)	Type(s) and comment
Combustible metals.....	0	
Low flash point liquids.....	0	
Explosive materials.....	0	
Phosphorus.....	0	
Hydrides.....	0	
Biological etc. materials.....	0	
Biodegradable materials.....	0	
Putrescible wastes.....	0	
Non-putrescible wastes.....		
Corrosive materials.....	0	
Pyrophoric materials.....	0	
Generating toxic gases.....	0	
Reacting with water.....	0	
Higher activity particles.....		
Soluble solids as bulk chemical compounds.....		

Hazardous substances / non hazardous pollutants:        None expected

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....		
Chlorinated solvents.....		
Formaldehyde.....		
Organometallics.....		
Phenol.....		

Styrene.....  
 Tri-butyl phosphate.....  
 Other organophosphates.....  
 Vinyl chloride.....  
 Arsenic.....  
 Barium.....  
 Boron..... 0  
     Boron (in Boral).....  
     Boron (non-Boral).....  
 Cadmium.....  
 Caesium.....  
 Selenium.....  
 Chromium.....  
 Molybdenum.....  
 Thallium.....  
 Tin.....  
 Vanadium.....  
 Mercury compounds.....  
 Others.....  
 Electronic Electrical Equipment (EEE)  
     EEE Type 1.....  
     EEE Type 2.....  
     EEE Type 3.....  
     EEE Type 4.....  
     EEE Type 5.....

Complexing agents (%wt):      No

(%wt)      Type(s) and comment

EDTA.....  
 DPTA.....  
 NTA.....  
 Polycarboxylic acids.....  
 Other organic complexants.....  
 Total complexing agents..... 0

Potential for the waste to contain discrete items:      Yes. Graphite Bricks/Tiles assumed to be DIs; may also include some HDRIs (e.g. steel pins) Large Metal Items (LMIs)/"substantial" thickness items considered "durable" assumed DIs; Stainless items assumed DIs

**PACKAGING AND CONDITIONING**

Conditioning method:      The graphite will be annealed to release the Wigner energy prior to packaging in to 6m3 boxes for long-term storage in the Harwell ILW Store  
 Plant Name:      BEPO waste packaging plant  
 Location:      Harwell  
 Plant startup date:      2025  
 Total capacity (m³/y incoming waste):      -

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Target start date for packaging this stream: 2025

Throughput for this stream (m³/y incoming waste): -

Other information: -

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m³)	Payload (m³)	Number of packages
	6m³ concrete box (SD)	100.0	2.895	5.8	194

Likely container type comment: -

Range in container waste volume: The waste loadings and payload factor given are for an average graphite package, which will form the majority of packages. Metals will be segregated and packaged separately, and will have a lower waste loading of ~2m3.

Other information on containers: -

Likely conditioning matrix: Pulverised Fly Ash / Ordinary Portland Cement

Other information: -

Conditioned density (t/m³): ~2.3

Conditioned density comment: Conditioned mass divided by payload volume for average graphite package. Density will be in the range 1.8 to 2.4 for other packages.

Other information on conditioning: -

Opportunities for alternative disposal routing: -

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Estimated Date that Opportunity will be realised	Opportunity Confidence	Comment
Disposal at a Geological Disposal Facility	Disposal at LLWR	NE	2025	Medium	Current characterisation data suggests half the inventory is LLW at time of retrieval. Unclear how much confidence there is in the characterisation data though.

## RADIOACTIVITY

Source: Activation of graphite and steel. There may be spot contamination of fission products.

Uncertainty: Alpha activity associated with the wastes is minimal as no fuel was damaged.

Definition of total alpha and total beta/gamma: Where totals are shown on the table of radionuclide activities they are the sums of the listed alpha or beta/gamma emitting radionuclides plus 'other alpha' or 'other beta/gamma'.

Measurement of radioactivities: Specific activities are based on a sampling campaign and calculations based on the operational life of the reactor, given in 2013 conceptual LoC submission 2013. Decay corrected to date of arising.

Other information: -

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Nuclide	Mean radioactivity, TBq/m <sup>3</sup>				Nuclide	Mean radioactivity, TBq/m <sup>3</sup>			
	Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3			7.92E-03	BB 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			1.96E-02	BB 2	Ho 166m				8
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			3.96E-05	CC 2	Lu 174				8
Ar 39				8	Lu 176				8
Ar 42				8	Hf 178n				8
K 40				8	Hf 182				8
Ca 41			1.31E-05	CC 2	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55			4.22E-06	CC 2	Pb 210				8
Co 60			1.95E-04	BB 2	Bi 208				8
Ni 59			1.05E-04	DD 2	Bi 210m				8
Ni 63			8.47E-03	DD 2	Po 210				8
Zn 65				8	Ra 223				8
Se 79				8	Ra 225				8
Kr 81				8	Ra 226				8
Kr 85				8	Ra 228				8
Rb 87				8	Ac 227				8
Sr 90				8	Th 227				8
Zr 93				8	Th 228				8
Nb 91				8	Th 229				8
Nb 92				8	Th 230				8
Nb 93m				8	Th 232				8
Nb 94			2.41E-06	DD 2	Th 234				8
Mo 93				8	Pa 231				8
Tc 97				8	Pa 233				8
Tc 99				8	U 232				8
Ru 106				8	U 233				8
Pd 107				8	U 234				8
Ag 108m				8	U 235				8
Ag 110m				8	U 236				8
Cd 109				8	U 238				8
Cd 113m			1.15E-07	DD 2	Np 237				8
Sn 119m				8	Pu 236				8
Sn 121m				8	Pu 238				8
Sn 123				8	Pu 239				8
Sn 126				8	Pu 240				8
Sb 125				8	Pu 241				8
Sb 126				8	Pu 242				8
Te 125m				8	Am 241				8
Te 127m				8	Am 242m				8
I 129				8	Am 243				8
Cs 134				8	Cm 242				8
Cs 135				8	Cm 243				8
Cs 137				8	Cm 244				8
Ba 133			2.79E-07	DD 2	Cm 245				8
La 137				8	Cm 246				8
La 138				8	Cm 248				8
Ce 144				8	Cf 249				8
Pm 145				8	Cf 250				8
Pm 147				8	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151			7.52E-07	DD 2	Other a				
Eu 152			6.32E-04	BB 2	Other b/g				
Eu 154			1.89E-04	BB 2	<b>Total a</b>	<b>0</b>	<b>0</b>		
Eu 155			1.6E-07	DD 2	<b>Total b/g</b>	<b>0</b>	<b>3.72E-02</b>	<b>DD 2</b>	

**Bands (Upper and Lower)**

- A a factor of 1.5
- B a factor of 3
- C a factor of 10
- D a factor of 100
- E a factor of 1000

Note: Bands quantify uncertainty in mean radioactivity.

**Code**

- 1 Measured activity
- 2 Derived activity (best estimate)
- 3 Derived activity (upper limit)
- 4 Not present
- 5 Present but not significant
- 6 Likely to be present but not assessed
- 7 Present in significant quantities but not determined
- 8 Not expected to be present in significant quantity