

<b>WASTE STREAM</b>	<b>2D24.3</b>	<b>MSSS Compartment 18</b>
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**SITE** Sellafield

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Sellafield Limited

**WASTE TYPE** ILW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

Stocks: At 1.4.2022..... Reported ~441.0 m<sup>3</sup>

Total future arisings: 0 m<sup>3</sup>

Total waste volume: 441.0 m<sup>3</sup>

Comment on volumes: There are no future arisings. Waste volume includes volume of swarf/sludge, miscellaneous beta/gamma and aggregate. Waste volumes are estimates derived from known fuel decanning campaigns and storage volumes.

Uncertainty factors on volumes: Stock (upper): x 1.5 Arisings (upper) x  
 Stock (lower): x 0.66 Arisings (lower) x

**WASTE SOURCE** Wastes associated with Magnox fuel decanning and their subsequent underwater storage.

**PHYSICAL CHARACTERISTICS**

General description: The waste is debris from the process of decanning Magnox reactor fuel elements. The waste has been stored under water since processing. The waste includes pieces of Magnox cans, fins and all other fuel element components, including fuel. Magnox components are corroded by the storage water, and partially converted to magnesium hydroxide as a fixed surface layer and a loose sludge. Fuel is similarly corroded to oxides of uranium. Swarf and uranium from Magnox decanning operations has reacted with storage cover water to form corrosion products.

Physical components (%wt): Magnox swarf (20.20%), Magnox sludge (21.39%), Al/Al(OH)<sub>3</sub> (0%), U/UO<sub>2</sub>/U<sub>3</sub>O<sub>8</sub> (11.47%), MBGW (scrap, filters, cans, etc.) (0%), aggregate (limestone) (0%), water (46.31%), others (0.64%). Includes interstitial liquor and cover liquor. Total volume including cover liquor 474 m<sup>3</sup>.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): ~0.83

Comment on density: Bulk density is solids only - includes water content based on assumptions of draining characteristics. Bulk density including interstitial liquor = 1.48t/m<sup>3</sup>, bulk density with cover liquor and interstitial liquor = 1.44t/m<sup>3</sup>. Average decanning debris is ~1.6t/m<sup>3</sup> and average MBGW is ~3.2t/m<sup>3</sup>.

**CHEMICAL COMPOSITION**

General description and components (%wt): Magnox swarf (20.20%), Magnox sludge (21.39%), Al/Al(OH)<sub>3</sub> (0%), U/UO<sub>2</sub>/U<sub>3</sub>O<sub>8</sub> (11.47%), MBGW (scrap, filters, cans, etc.) (0%), aggregate (limestone) (0%), water (46.31%), others (0.64%). Includes interstitial liquor and cover liquor. Total volume including cover liquor 474 m<sup>3</sup>.

Chemical state: Neutral

Chemical form of radionuclides: H-3: Present in elemental and reacted forms.  
 C-14: Present in elemental and reacted forms.  
 Cl-36: Present in elemental and reacted forms.  
 Se-79: Present in elemental and reacted forms.  
 Tc-99: Present in elemental and reacted forms.  
 I-129: Present in elemental and reacted forms.  
 Ra: Present in elemental forms  
 Th: Present in elemental and reacted forms.  
 U: Present in metallic and reacted forms (oxides and possibly hydride).  
 Np: Present in elemental and reacted forms.  
 Pu: Present in metallic and mixed oxide forms.

Metals and alloys (%wt): No significant quantities of sheet metal. Pieces of Magnox and uranium metal present.

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	~0.09	Mainly SS316 and SS304.	
Other ferrous metals.....	~4.6	Carbon steels.	
Iron.....	NE		
Aluminium.....	0		
Beryllium.....	NE		
Cobalt.....	NE		
Copper.....	NE		
Lead.....	NE		
Magnox/Magnesium.....	~19.3	Predominantly Magnox.	
Nickel.....	NE		
Titanium.....	NE		
Uranium.....	~7.3		
Zinc.....	NE		
Zircaloy/Zirconium.....	~0.05		
Other metals.....	~0.06		
Organics (%wt):	The organic content of the waste is low.		
	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulose.....	0		
Paper, cotton.....			
Wood.....			
Halogenated plastics .....	~0.06		
Total non-halogenated plastics.....	0		
Condensation polymers.....			
Others.....			
Organic ion exchange materials....	NE		
Total rubber.....	NE		
Halogenated rubber .....			
Non-halogenated rubber.....			
Hydrocarbons.....			
Oil or grease .....	~0.01		
Fuel.....	NE		
Asphalt/Tarmac (cont.coal tar)...	NE		
Asphalt/Tarmac (no coal tar)....	NE		
Bitumen.....	NE		
Others.....	NE		
Other organics.....	0		

Other materials (%wt):      -

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	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	NE		
Inorganic sludges and flocs.....	~24.0		
Soil.....	NE		
Brick/Stone/Rubble.....	0		
Cementitious material.....	NE		
Sand.....	NE		
Glass/Ceramics.....	~0.44		
Graphite.....	0		
Desiccants/Catalysts.....	NE		
Asbestos.....	NE		
Non/low friable.....			
Moderately friable.....			
Highly friable.....			
Free aqueous liquids.....	~44.1	Includes interstitial liquor and cover liquor. Total volume including cover liquor 474 m3.	
Free non-aqueous liquids.....	NE		
Powder/Ash.....	NE		

Inorganic anions (%wt):            Hydroxide and carbonate present.

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

Materials of interest for waste acceptance criteria:            Combustible metals are magnesium and uranium. Uranium hydride may be present but not quantified. Paper filter media are present as putrescible waste.

	(%wt)	Type(s) and comment
Combustible metals.....	0	
Low flash point liquids.....	0	
Explosive materials.....	0	
Phosphorus.....	0	
Hydrides.....	P	Trace, passivated.
Biological etc. materials.....	0	
Biodegradable materials.....		
Putrescible wastes.....	P	Cellulosics.

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Non-putrescible wastes.....	P	Organics - plastics and rubbers.
Corrosive materials.....	0	
Pyrophoric materials.....	P	
Generating toxic gases.....	0	
Reacting with water.....	P	<5%.
Higher activity particles.....	P	Radioactive sludges and solids.
Soluble solids as bulk chemical compounds.....	P	Elemental and hydroxides, oxides and carbonates.

Hazardous substances / Uranium and irradiated fuel components are present.  
non hazardous pollutants:

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....	0	
Chlorinated solvents.....		
Formaldehyde.....		
Organometallics.....		
Phenol.....	0	
Styrene.....		
Tri-butyl phosphate.....	0	
Other organophosphates.....		
Vinyl chloride.....	P	
Arsenic.....	0	
Barium.....		
Boron.....	NE	Traces - elemental and borates.
Boron (in Boral).....		
Boron (non-Boral).....		
Cadmium.....	0	
Caesium.....		
Selenium.....	0	
Chromium.....	P	In steels.
Molybdenum.....	P	In steels.
Thallium.....		
Tin.....	P	Traces.
Vanadium.....	*	In steels.
Mercury compounds.....		
Others.....	NE	
Electronic Electrical Equipment (EEE)		
EEE Type 1.....		
EEE Type 2.....		
EEE Type 3.....		
EEE Type 4.....		
EEE Type 5.....		

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Complexing agents (%wt):      Not yet determined

(%wt)      Type(s) and comment

EDTA.....

DPTA.....

NTA.....

Polycarboxylic acids.....

Other organic complexants.....

Total complexing agents.....

Potential for the waste to contain discrete items:      Not yet determined.

**PACKAGING AND CONDITIONING**

Conditioning method:      The waste will be retrieved from MSSS and stored in an unconditioned state for a period of 70 years. Following the period of storage it will be retrieved (from storage) and conditioned for ultimate disposal to the GDF.

Plant Name:      TBD

Location:      Sellafield

Plant startup date:      2070-2090

Total capacity (m<sup>3</sup>/y incoming waste):      -

Target start date for packaging this stream:      -

Throughput for this stream (m<sup>3</sup>/y incoming waste):      -

Other information:      The plant has not yet been designed. Hence, throughputs & capacities cannot be quoted at this time.

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m <sup>3</sup> )	Payload (m <sup>3</sup> )	Number of packages
	Sellafield enhanced 3m <sup>3</sup> box	100.0	0.560	2.15	788

Likely container type comment:      1 skip of retrieved waste (max 1,400 litres) in = 1 package out.

Range in container waste volume:      There will be considerable variability in unconditioned waste volume per package due to variations in skip loading and content. The actual number of packages produced is identified in the Sellafield Decommissioning Product and Secondary Waste Plan.788 Boxes = 718 Boxes plus 70 from residuals.

Other information on containers:      Stainless Steel.

Likely conditioning matrix:      BFS/OPC;PFA/OPC

Other information:      -

Conditioned density (t/m<sup>3</sup>):      ~2.0

Conditioned density comment:      Density of conditioned waste will be fairly uniform.

Other information on conditioning:      Waste matrix (as retrieved) will be in-filled with grout. A second pour of capping grout will be added. Void spaces between Skip wall and Box wall will be filled with grout.

Opportunities for alternative disposal routing:      No

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Baseline Management Route	Opportunity Management Route	Stream volume (%)	Estimated Date that Opportunity will be realised	Opportunity Confidence	Comment
-	-	-	-	-	-

## RADIOACTIVITY

Source:	Sr-90, Cs-137, Co-60, Pu-239, Pu-240, Pu-241 and Am-241.
Uncertainty:	Accuracy is generally good - based on decanning records arisings and fuel carry over evaluations.
Definition of total alpha and total beta/gamma:	FISPIN generates data for approximately 2500 radionuclides. Only a proportion of these are considered in the UK inventory for this waste stream.
Measurement of radioactivities:	Isotopic specific activity (TBq/m <sup>3</sup> ) is derived by dividing the estimated total activity of the isotope by the total volume of the waste.
Other information:	Short-lived daughters are included in the "other" beta/gamma activity.

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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	6.54E-07	AA 2			Gd 153	5.94E-19	AA 2		
Be 10	4.72E-07	AA 2			Ho 163	6.12E-11	AA 2		
C 14	6.46E-03	AA 2			Ho 166m	5.71E-07	AA 2		
Na 22					Tm 170	1.76E-35	AA 2		
Al 26					Tm 171	1.07E-09	AA 2		
Cl 36					Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40	1.84E-08	AA 2			Hf 182	1.31E-15	AA 2		
Ca 41	1.99E-04	AA 2			Pt 193				
Mn 53	5.56E-12	AA 2			Tl 204	3.36E-14	AA 2		
Mn 54					Pb 205				
Fe 55	6.69E-04	AA 2			Pb 210	1.80E-09	AA 2		
Co 60	9.91E-02	AA 2			Bi 208				
Ni 59	7.41E-03	AA 2			Bi 210m	1.46E-22	AA 2		
Ni 63	7.28E-01	AA 2			Po 210	1.73E-09	AA 2		
Zn 65					Ra 223	6.89E-08	AA 2		
Se 79	5.40E-05	AA 2			Ra 225	6.28E-11	AA 2		
Kr 81					Ra 226	5.74E-09	AA 2		
Kr 85	8.93E-01	AA 2			Ra 228				
Rb 87	3.33E-21	AA 2			Ac 227	2.70E-08	AA 2		
Sr 90	2.88E+01	AA 2			Th 227	2.68E-08	AA 2		
Zr 93	1.68E-03	AA 2			Th 228	2.09E-06	AA 2		
Nb 91					Th 229	6.30E-11	AA 2		
Nb 92	7.12E-15	AA 2			Th 230	6.67E-07	AA 2		
Nb 93m	1.35E-03	AA 2			Th 232	4.10E-13	AA 2		
Nb 94	9.74E-08	AA 2			Th 234	2.10E-03	AA 2		
Mo 93	4.63E-06	AA 2			Pa 231	5.53E-08	AA 2		
Tc 97					Pa 233	1.06E-04	AA 2		
Tc 99	1.37E-02	AA 2			U 232	2.03E-06	AA 2		
Ru 106	1.14E-08	AA 2			U 233	2.03E-08	AA 2		
Pd 107	9.98E-05	AA 2			U 234	1.85E-03	AA 2		
Ag 108m	1.54E-08	AA 2			U 235	5.03E-05	AA 2		
Ag 110m	2.74E-16	AA 2			U 236	2.19E-04	AA 2		
Cd 109	2.36E-16	AA 2			U 238	2.10E-03	AA 2		
Cd 113m	2.27E-14	AA 2			Np 237	1.06E-04	AA 2		
Sn 119m					Pu 236	5.24E-09	AA 2		
Sn 121m	1.72E-07	AA 2			Pu 238	3.38E-01	AA 2		
Sn 123					Pu 239	8.62E-01	AA 2		
Sn 126	7.32E-04	AA 2			Pu 240	1.00E+00	AA 2		
Sb 125	1.48E-03	AA 2			Pu 241	1.73E+01	AA 2		
Sb 126	1.02E-04	AA 2			Pu 242	6.01E-04	AA 2		
Te 125m	3.63E-04	AA 2			Am 241	2.63E+00	AA 2		
Te 127m					Am 242m	4.20E-03	AA 2		
I 129	3.02E-05	AA 2			Am 243	1.34E-03	AA 2		
Cs 134	2.34E-04	AA 2			Cm 242	3.47E-03	AA 2		
Cs 135	7.26E-04	AA 2			Cm 243	6.35E-04	AA 2		
Cs 137	4.29E+01	AA 2			Cm 244	9.16E-03	AA 2		
Ba 133	8.28E-10	AA 2			Cm 245	8.16E-07	AA 2		
La 137					Cm 246	5.94E-08	AA 2		
La 138	9.27E-14	AA 2			Cm 248				
Ce 144	2.00E-11	AA 2			Cf 249	4.38E-14	AA 2		
Pm 145					Cf 250	2.43E-14	AA 2		
Pm 147	1.93E-02	AA 2			Cf 251	3.85E-16	AA 2		
Sm 147					Cf 252	3.15E-18	AA 2		
Sm 151	3.36E-01	AA 2			Other a	8.66E-01			
Eu 152	2.10E-03	AA 2			Other b/g	6.94E+01			
Eu 154	1.48E-01	AA 2			<b>Total a</b>	<b>5.72E+00</b>	<b>AA 2</b>	<b>0</b>	
Eu 155	1.42E-02	AA 2			<b>Total b/g</b>	<b>1.61E+02</b>	<b>AA 2</b>	<b>0</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