

WASTE STREAM	5B34	DFR Breeder Fuel Removal Waste
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SITE Dounreay
SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Dounreay Site Restoration Limited

WASTE TYPE ILW

Is the waste subject to Scottish Policy: Yes

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	14.0 m ³
Future arisings -	1.4.2023 - 31.3.2024.....	3.0 m ³
	1.4.2031 - 31.3.2032.....	< 0.1 m ³
	1.4.2032 - 31.3.2033.....	0.6 m ³
	1.4.2033 - 31.3.2034.....	0.1 m ³
Total future arisings:		3.7 m ³
Total waste volume:		17.7 m ³

Comment on volumes: The waste will arise as a result of breeder fuel retrieval operations. Arisings dates based on provisional LTP programme data

Uncertainty factors on volumes: Stock (upper): x 1.02 Arisings (upper) x 1.2
 Stock (lower): x 0.98 Arisings (lower) x 0.8

WASTE SOURCE The waste will consist of breeder fuel cladding and associated operational wastes.

PHYSICAL CHARACTERISTICS

General description: The waste mostly comprises stainless steel and breeder fuel cladding.
 Physical components (%vol): Aluminium (0.19%), Ceramics (0.10%), Copper (3.94%), Glass (0.19%), Nickel (10.05%), Other (0.02%), Plastic (9.32%), Stainless steel (76.19%),
 Sealed sources: The waste does not contain sealed sources.
 Bulk density (t/m³): 2.265
 Comment on density: Bulk Density was taken from LoC

CHEMICAL COMPOSITION

General description and components (%wt): Aluminium (0.07%), Ceramics (0.05%), Copper (4.81%), Glass (0.07%), Nickel (12.20%), Plastic (1.17%), Stainless steel (81.63%),
 Chemical state: Neutral
 Chemical form of radionuclides: H-3: Present
 C-14: Present
 Cl-36: Present
 Se-79: Present
 Tc-99: Present
 I-129: Present
 Ra: Present
 Th: Present
 U: Present
 Np: Present
 Pu: Present
 Metals and alloys (%wt): Stainless steel present as drums, thin tubing and bulk end fittings.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	81.6	Assumed to be M316.	
Other ferrous metals.....			
Iron.....			
Aluminium.....	0.07		
Beryllium.....	NE		

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Cobalt.....	0
Copper.....	4.8
Lead.....	0
Magnox/Magnesium.....	0
Nickel.....	12.2
Titanium.....	
Uranium.....	TR
Zinc.....	0
Zircaloy/Zirconium.....	0
Other metals.....	Antimony, Uranium

Organics (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulose.....	0		
Paper, cotton.....	0		
Wood.....	0		
Halogenated plastics	1.2		
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.....	0		
Glass/Ceramics.....	0.12		
Graphite.....	0		

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Desiccants/Catalysts.....	0
Asbestos.....	0
Non/low friable.....	
Moderately friable.....	
Highly friable.....	
Free aqueous liquids.....	0
Free non-aqueous liquids.....	0
Powder/Ash.....	0

Inorganic anions (%wt): No inorganic anions are present in the waste.

	(%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: Uranium metal is present.

	(%wt)	Type(s) and comment
Combustible metals.....	0.50	
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.....	0	
Corrosive materials.....	0	
Pyrophoric materials.....	0	
Generating toxic gases.....	0	
Reacting with water.....	0.50	
Higher activity particles.....	NE	
Soluble solids as bulk chemical compounds.....	0	

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non hazardous pollutants:

There are no toxic metals present in the waste.

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....	NE	
Chlorinated solvents.....		
Formaldehyde.....		
Organometallics.....		
Phenol.....	NE	
Styrene.....		
Tri-butyl phosphate.....	NE	
Other organophosphates.....		
Vinyl chloride.....	NE	
Arsenic.....	NE	
Barium.....		
Boron.....	NE	
Boron (in Boral).....		
Boron (non-Boral).....		
Cadmium.....	NE	
Caesium.....		
Selenium.....	NE	
Chromium.....	NE	
Molybdenum.....	NE	
Thallium.....		
Tin.....	NE	
Vanadium.....	NE	
Mercury compounds.....		
Others.....	NE	
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	

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

PACKAGING AND CONDITIONING

Conditioning method: The waste will be packaged into 160 l crates inside Z6033 200 litre drums. The drums will be packaged into 500 litre drums in the future.

Plant Name: RHILW Repackaging Facility

Location: Dounreay

Plant startup date: 2028

Total capacity (m³/y incoming waste): -

Target start date for packaging this stream: 2028

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

Other information: RHILW Repackaging Plant is currently in the design phase.

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m ³)	Payload (m ³)	Number of packages
	500 l drum	100.0	~0.27	0.5	66

Likely container type comment: -

Range in container waste volume: Waste loading will be variable and dependant on nuclear material content of the wastes. Assume 3:2 Z6033 to 500L drum ratio. Assume Z6033 loading @ 0.2m³=0.6m³ in 2 500L drums (1m³) = 0.3m³ per 500L drum.

Other information on containers: -

Likely conditioning matrix: Cement

Other information: -

Conditioned density (t/m³): ~2.5

Conditioned density comment: Density is if waste is grouted directly into 500 litre drums. Assume density similar to CHILW repack.

Other information on conditioning: -

Opportunities for alternative disposal routing: No

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

RADIOACTIVITY

Source: The main source of activity is the activated cladding and minor contamination from irradiated breeder fuel debris.

Uncertainty: Specific activities are best estimates on computer modelling. Both stocks and arisings data taken from LoC. Specific activities calculated using separate stocks and arisings volumes.

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'.

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Measurement of
radioactivities:

Data taken from LoC

Other information:

Specific Activities are from UKRWI 2019 decayed to 2022.

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Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	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	2.32E-04	CC 2	3.19E-04	CC 2	Gd 153				
Be 10					Ho 163				
C 14	7.01E-04	CC 2	7.01E-04	CC 2	Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36	6.62E-08	CC 2	6.62E-08	CC 2	Lu 174				
Ar 39	1.38E-04	CC 2	1.41E-04	CC 2	Lu 176				
Ar 42	2.95E-09	CC 2	3.33E-09	CC 2	Hf 178n				
K 40					Hf 182				
Ca 41	5.11E-06	CC 2	5.11E-06	CC 2	Pt 193				
Mn 53					Tl 204				
Mn 54					Pb 205	4.06E-10	CC 2	4.06E-10	CC 2
Fe 55					Pb 210			1.70E-16	CC 2
Co 60	2.22E-04	CC 2	4.38E-04	CC 2	Bi 208	3.44E-10	CC 2	3.44E-10	CC 2
Ni 59	2.32E-03	CC 2	2.32E-03	CC 2	Bi 210m	5.69E-10	CC 2	5.69E-10	CC 2
Ni 63	7.25E-02	CC 2	7.55E-02	CC 2	Po 210			1.03E-16	CC 2
Zn 65					Ra 223			3.61E-14	CC 2
Se 79	7.92E-08	CC 2	7.92E-08	CC 2	Ra 225			1.72E-10	CC 2
Kr 81	1.60E-08	CC 2	1.60E-08	CC 2	Ra 226			5.65E-15	CC 2
Kr 85	7.07E-06	CC 2	1.01E-05	CC 2	Ra 228			1.39E-23	CC 2
Rb 87					Ac 227	1.86E-09	CC 2	3.91E-14	CC 2
Sr 90	2.87E-04	CC 2	3.30E-04	CC 2	Th 227			3.67E-14	CC 2
Zr 93					Th 228			3.50E-08	CC 2
Nb 91					Th 229			1.76E-10	CC 2
Nb 92	9.31E-10	CC 2	9.31E-10	CC 2	Th 230			8.70E-12	CC 2
Nb 93m					Th 232			1.26E-22	CC 2
Nb 94	8.89E-03	CC 2	8.89E-03	CC 2	Th 234			3.13E-07	CC 2
Mo 93	6.56E-04	CC 2	6.57E-04	CC 2	Pa 231			8.46E-13	CC 2
Tc 97					Pa 233			2.61E-12	CC 2
Tc 99	5.10E-05	CC 2	5.10E-05	CC 2	U 232	4.92E-08	CC 2	5.22E-08	CC 2
Ru 106					U 233	6.20E-07	CC 2	6.20E-07	CC 2
Pd 107					U 234	3.15E-07	CC 2	3.15E-07	CC 2
Ag 108m					U 235	1.33E-08	CC 2	1.33E-08	CC 2
Ag 110m					U 236			1.71E-12	CC 2
Cd 109					U 238	3.13E-07	CC 2	3.13E-07	CC 2
Cd 113m	4.75E-05	CC 2	6.29E-05	CC 2	Np 237			2.70E-12	CC 2
Sn 119m					Pu 236				
Sn 121m					Pu 238	4.17E-06	CC 2	4.37E-06	CC 2
Sn 123					Pu 239	4.94E-04	CC 2	4.94E-04	CC 2
Sn 126					Pu 240	1.94E-05	CC 2	1.94E-05	CC 2
Sb 125					Pu 241	2.52E-06	CC 2	3.32E-06	CC 2
Sb 126					Pu 242				
Te 125m					Am 241	2.78E-06	CC 2	2.78E-06	CC 2
Te 127m					Am 242m				
I 129	9.52E-10	CC 2	9.52E-10	CC 2	Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	4.64E-04	CC 2	5.30E-04	CC 2	Cm 244				
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145					Cf 250				
Pm 147					Cf 251				
Sm 147					Cf 252				
Sm 151					Other a			1.28E-07	CC 2
Eu 152					Other b/g			8.30E-04	CC 2
Eu 154					Total a	5.21E-04	CC 2	5.22E-04	CC 2
Eu 155					Total b/g	8.65E-02	CC 2	9.09E-02	CC 2

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