WASTE STREAM 2S313 Windscale Piles Miscellaneous ILW

SITE	Windscale
SITE OWNER	Nuclear Decommissioning Authority
WASTE CUSTODIAN	Sellafield Limited
WASTE TYPE	ILW
Is the waste subject to Scottish Policy:	No

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	6.8 m^3
Future arisings -	1.4.2022 - 31.3.2023.....	0 m^3
	1.4.2023 - 31.3.2024.....	0 m^3
	1.4.2024 - 31.3.2025.....	0 m^3
	1.4.2025 - 31.3.2042.....	0 m^3
	1.4.2042 - 31.3.2053.....	~798.0 m^3
Total future arisings:		798.0 m^3
Total waste volume:		804.8 m^3

Comment on volumes: The stocks are made up from water duct debris and other waste from decommissioning on Piles and the Ex-PIE Facility that is currently stored within Pile 2. The waste arisings will be produced through decommissioning of the Piles reactors in line with the Piles optimised plan. The volumes given are envelope volumes.

Uncertainty factors on volumes:

Stock (upper):	x 1.5	Arisings (upper)	x 1.5
Stock (lower):	x 0.5	Arisings (lower)	x 0.5

WASTE SOURCE Decommissioning of the Windscale Piles reactors.

PHYSICAL CHARACTERISTICS

General description: This is the non graphite/ fuel/ isotope component waste including metal core structural support components, such as external components including the control and shut-off rods and Burst Slug Scanning Gear. The waste is likely to be subject to fuel contamination following the fire in Pile 1. The concrete bioshield is now believed to be either exempt or LLW. In addition to this the waste stream also includes the water duct debris and contents of 6 flasks currently stored in Pile 2. The waste in the pile reactors have remained in the reactors in a care and maintenance regime since they shut down. The waste in the Pile 1 reactor was subject to fire conditions.

Physical components (%wt): Carbon steel components (12%), Thermal Shield (81.6%), core stainless steel (0.3%), Aluminium (0.6%), Cast iron (2.1%), BSSG (0.7%), Boronated steel (0.3%), Asbestos (1.4%), Fibreglass (0.7%), Mild steel components (0.2%), Concrete plug (<0.1%), Lead (<0.1%), Polythene (<0.1%), Brass (leaded) (<<0.1%), Cadmium (<0.1%), Water duct debris (<<0.1%), Drummed waste (<<0.1%).

Sealed sources: The waste contains sealed sources.

Bulk density (t/m^3): ~2.8

Comment on density: Density has been calculated from waste stream mass and envelope volume.

CHEMICAL COMPOSITION

General description and components (%wt): Carbon Steel (93.6%), Stainless steel (1%), Aluminium (0.6%), Cast Iron (2.1%), Boronated Steel (0.3%), Asbestos (1.4%), Fibreglass (0.7%), Mild steel (0.2%), Concrete (<0.1%), Lead (<0.1%), Polythene (<0.1%), Brass (leaded) (<<0.1%), Cadmium (<0.1%), Water duct debris (<<0.1%), Drummed waste (<<0.1%).

Chemical state: Neutral

Chemical form of radionuclides:
H-3: Present in the waste as an activation product.
C-14: Present in the waste as an activation product.
Se-79: Present in the waste as an activation product.
Tc-99: Present in the waste as an activation product.
Ra: Present in the waste as an activation product.
Th: Present in the waste as an activation product.
U: Present due to fuel contaminantion. May be present as uranium metal and compounds from reaction.
Np: Present in the waste as an activation product.

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Pu: Present in the waste as an activation product.

Metals and alloys (%wt): The bulk metal items present includes the thermal shield, Al cascade vanes (12x 2.2x 2.2 m), Al N girders (6.4x 1.7x 0.9 m), BSSG (16.5x 0.36x 15.2 m), stainless steel bars (7.43m long), control and shutdown rods (10m long boronated steel sheathed in stainless steel), insulation boxes each made of 2 carbon steel sheets (vol 4.6m³ each), and the core contains 8.9 m³ carbon steel rebar.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel	~1.0		
Other ferrous metals	~94.1		100.0
Iron	~2.1		
Aluminium	~0.60		
Beryllium			
Cobalt	0		
Copper	<<0.01		
Lead	<0.10		
Magnox/Magnesium	0		
Nickel	0		
Titanium			
Uranium	P		
Zinc	0		
Zircaloy/Zirconium	0		
Other metals	<<0.10	Brass (leaded) and cadmium.	

Organics (%wt): Trace amounts of rubber and wood may be present in the water duct debris. Trace amounts of foam rubber may be present in the water duct debris.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics	TR		
Paper, cotton	0		
Wood	TR		
Halogenated plastics	0		
Total non-halogenated plastics	<0.10		
Condensation polymers			
Others			
Organic ion exchange materials	0		
Total rubber	TR		
Halogenated rubber	NE		
Non-halogenated rubber	NE		
Hydrocarbons			
Oil or grease			
Fuel			
Asphalt/Tarmac (cont.coal tar)			
Asphalt/Tarmac (no coal tar)			
Bitumen			
Others			
Other organics	<0.10		

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Other materials (%wt): The sluges/ flocs, rubble, glass and graphite are present in the water duct debris. The concrete is part of the water duct debris and also the concrete plugs found in the ion chambers.

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	0		
Inorganic sludges and flocs.....	NE		
Soil.....	0		
Brick/Stone/Rubble.....	TR		
Cementitious material.....	<0.10		
Sand.....			
Glass/Ceramics.....	~0.70		
Graphite.....	TR		
Desiccants/Catalysts.....			
Asbestos.....	~1.4		
Non/low friable.....			
Moderately friable.....			
Highly friable.....			
Free aqueous liquids.....	P		
Free non-aqueous liquids.....	0		
Powder/Ash.....	0		

Inorganic anions (%wt): Carbonates present in concrete. Chlorides could be present due to the effects the Pile 1 fire may have had on the Potassium Chloride cartridges.

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

Materials of interest for waste acceptance criteria: Aqueous liquids are present as part of the water duct debris.

	(%wt)	Type(s) and comment
Combustible metals.....	0	
Low flash point liquids.....	0	
Explosive materials.....	0	
Phosphorus.....	0	
Hydrides.....	0	
Biological etc. materials.....	0	

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Biodegradable materials.....	NE
Putrescible wastes.....	0
Non-putrescible wastes.....	NE
Corrosive materials.....	0
Pyrophoric materials.....	0
Generating toxic gases.....	0
Reacting with water.....	0
Higher activity particles.....	NE
Soluble solids as bulk chemical compounds.....	NE

Hazardous substances / non hazardous pollutants: Cadmium and asbestos are present in small amounts.

	(%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.....		

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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. Tools and steel fabrications are likely to be present in this waste stream.

PACKAGING AND CONDITIONING

Conditioning method: Yet to be confirmed.

Plant Name: -

Location: Sellafield.

Plant startup date: Dependent on conditioning option chosen.

Total capacity (m^3/y incoming waste): NE

Target start date for packaging this stream: -

Throughput for this stream (m^3/y incoming waste): NE

Other information: -

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
Sellafield 3m^3 box	100.0	~0.485	~2.15	1662

Likely container type comment: The current strategy for the water duct is for it to be transferred to and packaged at another NDA site, this strategy may be reviewed at a later date.

Range in container waste volume: The loading will vary with the type of waste being packaged, and decommissioning and packaging strategy.

Other information on containers: The waste container design is still being developed.

Likely conditioning matrix: PFA/OPC;None

Other information: -

Conditioned density (t/m^3): ~2.3

Conditioned density comment: Density assuming ferrous scrap and standard cementitious grout.

Other information on conditioning: -

Opportunities for alternative disposal routing: Not yet determined

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

RADIOACTIVITY

Source:	The radionuclide inventory is dominated by activation products. It is also influenced by the fuel contamination resulting from the fire in Pile 1.
Uncertainty:	The main source of uncertainty in the activation modelling is the elemental uncertainties in the material compositions. Wherever possible specific compositions and trace element data were used for each component.
Definition of total alpha and total beta/gamma:	.
Measurement of radioactivities:	AEA Technology was commissioned to undertake WIMS, ANISN and FISPIN modelling for the Pile reactor to establish the inventory of the main components and to establish the waste category of these components in support of the Piles LoC submissions.
Other information:	-

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Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3	7.44E-03	B B 2	5.31E-03	B B 2	Gd 153				
Be 10	1.10E-07	B B 2	1.10E-07	B B 2	Ho 163	2.05E-07	B B 2	2.04E-07	B B 2
C 14	3.93E-03	B B 2	3.93E-03	B B 2	Ho 166m	2.23E-05	B B 2	2.23E-05	B B 2
Na 22					Tm 170				
Al 26					Tm 171	4.63E-13	B B 2	5.32E-14	B B 2
Cl 36	5.45E-07	B B 2	5.45E-07	B B 2	Lu 174	1.28E-12	B B 2	3.91E-13	B B 2
Ar 39	5.14E-04	B B 2	5.06E-04	B B 2	Lu 176	6.66E-11	B B 2	6.66E-11	B B 2
Ar 42	3.27E-10	B B 2	2.88E-10	B B 2	Hf 178n	2.12E-05	B B 2	1.85E-05	B B 2
K 40	7.51E-09	B B 2	7.51E-09	B B 2	Hf 182	8.46E-13	B B 2	8.46E-13	B B 2
Ca 41	2.30E-05	B B 2	2.30E-05	B B 2	Pt 193	2.49E-05	B B 2	2.29E-05	B B 2
Mn 53	1.14E-08	B B 2	1.14E-08	B B 2	Tl 204	1.18E-06	B B 2	3.93E-07	B B 2
Mn 54	9.37E-23	B B 2	7.25E-25	B B 2	Pb 205	4.85E-09	B B 2	4.85E-09	B B 2
Fe 55	8.31E-06	B B 2	1.81E-06	B B 2	Pb 210	7.84E-13	B B 2	7.50E-13	B B 2
Co 60	7.09E-03	B B 2	3.23E-03	B B 2	Bi 208	1.95E-10	B B 2	1.95E-10	B B 2
Ni 59	1.37E-02	B B 2	1.37E-02	B B 2	Bi 210m	6.96E-10	B B 2	6.96E-10	B B 2
Ni 63	1.10E+00	B B 2	1.06E+00	B B 2	Po 210	7.85E-13	B B 2	7.49E-13	B B 2
Zn 65	5.64E-30	B B 2	1.12E-32	B B 2	Ra 223	5.44E-10	B B 2	5.56E-10	B B 2
Se 79	2.21E-08	B B 2	2.21E-08	B B 2	Ra 225	5.62E-09	B B 2	5.25E-09	B B 2
Kr 81	7.13E-08	B B 2	7.13E-08	B B 2	Ra 226	7.80E-13	B B 2	8.58E-13	B B 2
Kr 85	1.35E-05	B B 2	9.19E-06	B B 2	Ra 228	1.73E-08	B B 2	1.73E-08	B B 2
Rb 87	1.31E-07	B B 2	1.31E-07	B B 2	Ac 227	5.44E-10	B B 2	5.57E-10	B B 2
Sr 90	1.08E-05	B B 2	9.44E-06	B B 2	Th 227	5.36E-10	B B 2	5.49E-10	B B 2
Zr 93	1.36E-08	B B 2	1.36E-08	B B 2	Th 228	2.23E-08	B B 2	2.17E-08	B B 2
Nb 91	2.73E-07	B B 2	2.71E-07	B B 2	Th 229	5.63E-09	B B 2	5.25E-09	B B 2
Nb 92	7.85E-11	B B 2	7.85E-11	B B 2	Th 230	4.67E-11	B B 2	4.40E-11	B B 2
Nb 93m	1.52E-03	B B 2	1.20E-03	B B 2	Th 232	1.73E-08	B B 2	1.73E-08	B B 2
Nb 94	1.86E-03	B B 2	1.86E-03	B B 2	Th 234	6.83E-08	B B 2	6.83E-08	B B 2
Mo 93	1.91E-04	B B 2	1.92E-04	B B 2	Pa 231	6.18E-10	B B 2	6.18E-10	B B 2
Tc 97	6.82E-11	B B 2	6.82E-11	B B 2	Pa 233	5.10E-11	B B 2	4.79E-11	B B 2
Tc 99	2.29E-05	B B 2	2.29E-05	B B 2	U 232	4.95E-09	B B 2	4.66E-09	B B 2
Ru 106	7.00E-24	B B 2	1.15E-25	B B 2	U 233	9.78E-07	B B 2	9.78E-07	B B 2
Pd 107	7.04E-10	B B 2	7.04E-10	B B 2	U 234	7.30E-08	B B 2	7.30E-08	B B 2
Ag 108m	1.99E-05	B B 2	1.97E-05	B B 2	U 235	3.13E-09	B B 2	3.13E-09	B B 2
Ag 110m	4.34E-31	B B 2	1.44E-33	B B 2	U 236	1.29E-10	B B 2	1.29E-10	B B 2
Cd 109	1.15E-18	B B 2	4.30E-20	B B 2	U 238	6.83E-08	B B 2	6.83E-08	B B 2
Cd 113m	3.58E-05	B B 2	2.65E-05	B B 2	Np 237	5.11E-11	B B 2	4.80E-11	B B 2
Sn 119m	6.94E-27	B B 2	3.88E-29	B B 2	Pu 236	1.10E-20	B B 2	2.63E-21	B B 2
Sn 121m	1.16E-05	B B 2	1.08E-05	B B 2	Pu 238	7.53E-08	B B 2	7.18E-08	B B 2
Sn 123					Pu 239	1.56E-05	B B 2	1.56E-05	B B 2
Sn 126	2.53E-11	B B 2	2.53E-11	B B 2	Pu 240	9.81E-07	B B 2	9.81E-07	B B 2
Sb 125	2.27E-09	B B 2	5.20E-10	B B 2	Pu 241	3.63E-06	B B 2	2.72E-06	B B 2
Sb 126					Pu 242	2.74E-10	B B 2	2.74E-10	B B 2
Te 125m	5.69E-10	B B 2			Am 241	2.52E-06	B B 2	2.53E-06	B B 2
Te 127m					Am 242m	2.19E-09	B B 2	2.13E-09	B B 2
I 129	2.24E-11	B B 2	2.24E-11	B B 2	Am 243	2.32E-10	B B 2	2.32E-10	B B 2
Cs 134	2.69E-11	B B 2	3.56E-12	B B 2	Cm 242	1.81E-09	B B 2	1.76E-09	B B 2
Cs 135	8.65E-10	B B 2	8.65E-10	B B 2	Cm 243	7.92E-11	B B 2	6.87E-11	B B 2
Cs 137	1.15E-05	B B 2	1.00E-05	B B 2	Cm 244	2.17E-10	B B 2	1.72E-10	B B 2
Ba 133	4.21E-05	B B 2	2.85E-05	B B 2	Cm 245	2.93E-14	B B 2	2.93E-14	B B 2
La 137	3.75E-07	B B 2	3.75E-07	B B 2	Cm 246	1.41E-15	B B 2	1.40E-15	B B 2
La 138	4.41E-13	B B 2	4.41E-13	B B 2	Cm 248	1.07E-22	B B 2	1.07E-22	B B 2
Ce 144	9.79E-29	B B 2	4.72E-31	B B 2	Cf 249	1.14E-22	B B 2	1.12E-22	B B 2
Pm 145	4.66E-07	B B 2	3.69E-07	B B 2	Cf 250				
Pm 147	1.17E-11	B B 2	2.38E-12	B B 2	Cf 251				
Sm 147	3.43E-11	B B 2	3.43E-11	B B 2	Cf 252				
Sm 151	2.88E-05	B B 2	2.76E-05	B B 2	Other a				
Eu 152	3.77E-04	B B 2	2.77E-04	B B 2	Other b/g				
Eu 154	3.79E-05	B B 2	2.34E-05	B B 2	**Total a**	**2.03E-05**	**B B 2**	**2.04E-05**	**B B 2**
Eu 155	5.53E-08	B B 2	2.34E-08	B B 2	**Total b/g**	**1.14E+00**	**B A 2**	**1.09E+00**	**B B 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