

<b>WASTE STREAM</b>	<b>2D11</b>	<b>Pond Sludge</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**

		Reported
Stocks:	At 1.4.2022.....	296.0 m <sup>3</sup>
Total future arisings:		0 m <sup>3</sup>
Total waste volume:		296.0 m <sup>3</sup>

Comment on volumes: There are no future arisings. Sludge is to be removed from pond. Volumes stated based on current MPS. Estimate of pond sludge volumes indicates uncertainty in the range from 260 to 390m<sup>3</sup> from previous estimate, and also reflects the 27m<sup>3</sup> sludge exported to WEP since December 2016.

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

**WASTE SOURCE** The waste is from corrosion of items stored in the pond, the pond structure and general pond debris (eg. wind blown, wildlife deposition).

**PHYSICAL CHARACTERISTICS**

General description: The sludge is a dark, brownish-green, flocculant material containing a small proportion by volume of gritty material. It comprises approx 14.5 wt% solids in aqueous medium. No large items present. The waste has not undergone any change since it was generated.

Physical components (%wt): Water (86.5 wt%), solids (13.5 wt%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): 1.1

Comment on density: The given density is the material density. Samples taken in October 1987 had a settled wet density of 1.0 - 1.2 t/m<sup>3</sup> and a solids concentration of up to 22 wt%.

**CHEMICAL COMPOSITION**

General description and components (%wt): Fe (1.3%), Mg (1.2%), Zn (0.1%), Al (0.1%), mostly as oxides. Others include U (0.6%), Pu (6E-4%). The most recent sampling indicates that the soluble organic fraction is less than 1%. Also H<sub>2</sub>O (85.5%), SiO<sub>2</sub> (balance).

Chemical state: Alkali

Chemical form of radionuclides: Th: No characterisation data available.  
 U: Oxides.  
 Pu: Oxides.

Metals and alloys (%wt): No sheet or bulk metal is present.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	0		
Other ferrous metals.....	P	Trace within sludge matrix from corrosion.	
Iron.....	~1.3		
Aluminium.....	~0.10		
Beryllium.....	TR		
Cobalt.....	0		
Copper.....	0		
Lead.....	0		
Magnox/Magnesium.....	~1.2		

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Nickel.....		
Titanium.....	0	
Uranium.....	~0.60	May be traces of uranium metal
Zinc.....	~0.10	
Zircaloy/Zirconium.....	0	
Other metals.....	TR	

Organics (%wt): Most recent study found <1% ether or chloroform extractable organics. Any organic matter will have arisen from bird droppings and bioactivity in the pond. There are no organic ion exchange resins, and cellulosic material is not expected to be 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.....	P		

Other materials (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	0		
Inorganic sludges and flocs.....	~72.7		
Soil.....	0		
Brick/Stone/Rubble.....	TR		
Cementitious material.....	TR		
Sand.....	~24.0	Assumed from MAIS, could also be concrete dust.	
Glass/Ceramics.....			
Graphite.....	TR		
Desiccants/Catalysts.....	0		
Asbestos.....	0		
Non/low friable.....			

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Moderately friable.....

Highly friable.....

Free aqueous liquids..... ~0

Free non-aqueous liquids..... 0

Powder/Ash..... 0

Inorganic anions (%wt): Waste contains traces of phosphates from guano, plus traces of chlorides, sulphates and carbonates from concrete pond structure.

	(%wt)	Type(s) and comment
Fluoride.....	NE	
Chloride.....	<0.05	
Iodide.....	NE	
Cyanide.....	0	
Carbonate.....	TR	
Nitrate.....	NE	
Nitrite.....	P	
Phosphate.....	TR	
Sulphate.....	TR	
Sulphide.....	NE	

Materials of interest for waste acceptance criteria: The waste may contain metallic Magnox (fragments from incomplete corrosion of Magnox cladding/swarf), bird droppings, cyanobacteria and algae.

	(%wt)	Type(s) and comment
Combustible metals.....	P	<1%.
Low flash point liquids.....	0	
Explosive materials.....	0	
Phosphorus.....	0	
Hydrides.....	0	
Biological etc. materials.....	P	<1%.
Biodegradable materials.....	0	
Putrescible wastes.....	0	
Non-putrescible wastes.....	0	
Corrosive materials.....	0	
Pyrophoric materials.....	0	
Generating toxic gases.....	0	
Reacting with water.....	0	
Higher activity particles.....	0	
Soluble solids as bulk chemical compounds.....	0	

Hazardous substances / non hazardous pollutants: Oxides (and possible metal fragments) of uranium, plutonium, barium and beryllium (from Magnox corrosion).

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....	0	

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

Complexing agents (%wt): Not yet determined

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids.....	0	
Other organic complexants.....	NE	Not estimated but unlikely to be present.
Total complexing agents.....	NE	

Potential for the waste to contain discrete items: No.

**PACKAGING AND CONDITIONING**

Conditioning method: Sludge encapsulation.

Plant Name: Local sludge treatment plant (LSTP) & Drum Filling plant.

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Location: Sellafield.

Plant startup date: December 2016.

Total capacity (m<sup>3</sup>/y incoming waste): ~296.0

Target start date for packaging this stream: 2016

Throughput for this stream (m<sup>3</sup>/y incoming waste): ~50.0

Other information: Currently the method used to pacify the sludge is to be encapsulated in WEP.

LSTP export plant capacity assumptions: treat up to 50m<sup>3</sup> of sludge each year from 2016 to 2026, with exports taken to WEP.

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m <sup>3</sup> )	Payload (m <sup>3</sup> )	Number of packages
	500 l drum	100.0	~0.25	0.47	1184

Likely container type comment: Sludge is dewatered by settling/decant and then homogenised and transferred to WEP in drums for final conditioning in line with WEP CfA and LoC requirements.

Range in container waste volume: Limited range. Drums should be full in most cases.

Other information on containers: Stainless steel.

Likely conditioning matrix: Cement;BFS/OPC;PFA/OPC

Other information: -

Conditioned density (t/m<sup>3</sup>): ~1.6

Conditioned density comment: This is the bulk density of the waste ~1.1 t/m<sup>3</sup> with the addition of conditioning material.

Other information on conditioning: -

Opportunities for alternative disposal routing: Not yet determined

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

## RADIOACTIVITY

Source: The source of the activity is corrosion debris from fuel elements, isotope cartridges and miscellaneous active wastes stored in the pond. The main components are Cs-137 and Sr-90, with isotopes of Mn, Co, Zr, Ru, Nb, Ce, Sb, Am, U, Pu and Eu also present.

Uncertainty: The accuracy of the information is the best available. It is derived from 2 separate sampling exercises, yielding 21 samples from various areas of the pond, and from sampling of 14 batches of PFSP sludge processed through the Local Sludge Treatment Plant before export to WEP. Wide variations were observed in the analyses of differing samples.

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: By theoretical calculation, except Cs and Sr which are measured activities.

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Other information:

Other alpha and other beta/gamma nuclides not specified.

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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					Gd 153				
Be 10					Ho 163				
C 14					Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36	3.35E-06	BB 2			Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54	1.69E-15	AA 2			Pb 205				
Fe 55					Pb 210	2.59E-12	CC 2		
Co 60	5.03E-06	BC 2			Bi 208				
Ni 59					Bi 210m				
Ni 63	1.38E-03	CC 2			Po 210	2.40E-12	CC 2		
Zn 65					Ra 223	2.52E-10	CC 2		
Se 79					Ra 225	4.61E-14	CC 2		
Kr 81					Ra 226	1.40E-11	CC 2		
Kr 85					Ra 228				
Rb 87					Ac 227	2.53E-10	CC 2		
Sr 90	1.71E-01	CD 2			Th 227	2.49E-10	CC 2		
Zr 93	1.70E-06	CC 2			Th 228				
Nb 91					Th 229	4.64E-14	CC 2		
Nb 92					Th 230	3.09E-09	CC 2		
Nb 93m	9.94E-07	CC 2			Th 232				
Nb 94					Th 234	1.60E-05	CC 2		
Mo 93					Pa 231	6.46E-10	CC 2		
Tc 97					Pa 233	6.86E-07	CC 2		
Tc 99	6.70E-06	CC 2			U 232				
Ru 106	5.41E-13	BC 2			U 233	5.09E-11	CC 2		
Pd 107					U 234	1.60E-05	CC 2		
Ag 108m					U 235	6.40E-07	CC 2		
Ag 110m					U 236	1.99E-09	CD 2		
Cd 109					U 238	1.60E-05	CC 2		
Cd 113m					Np 237	6.87E-07	CC 2		
Sn 119m					Pu 236				
Sn 121m					Pu 238	5.05E-04	CD 2		
Sn 123					Pu 239	4.80E-04	CD 2		
Sn 126					Pu 240	3.19E-03	CD 2		
Sb 125	1.97E-07	BC 2			Pu 241	1.96E-03	CD 2		
Sb 126					Pu 242	6.40E-07	CD 2		
Te 125m	4.93E-08	BC 2			Am 241	3.69E-02	CD 2		
Te 127m					Am 242m				
I 129	1.30E-09	CC 2			Am 243	5.58E-07	CC 2		
Cs 134	2.66E-09	BC 2			Cm 242				
Cs 135	3.30E-07	CC 2			Cm 243				
Cs 137	6.96E-02	BD 2			Cm 244	1.01E-06	CC 2		
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144	1.77E-18	CC 2			Cf 249				
Pm 145					Cf 250				
Pm 147	9.02E-07	CC 2			Cf 251				
Sm 147	5.72E-15	CC 2			Cf 252				
Sm 151	1.98E-04	CC 2			Other a	5.65E-02	CD 2		
Eu 152	3.16E-05	CC 2			Other b/g	3.83E-01	CC 2		
Eu 154	9.88E-05	AB 2			<b>Total a</b>	<b>9.76E-02</b>	<b>CD 1</b>		<b>0</b>
Eu 155	1.55E-05	CC 2			<b>Total b/g</b>	<b>6.28E-01</b>	<b>CD 1</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