

<b>WASTE STREAM</b>	<b>5C41</b>	<b>Operational LLW Sludge</b>
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**SITE** Harwell  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Magnox Limited  
**WASTE TYPE** LLW  
 Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2022.....	~9.0 m <sup>3</sup>
Total future arisings:		0 m <sup>3</sup>
Total waste volume:		9.0 m <sup>3</sup>
Comment on volumes:	-	
Uncertainty factors on volumes:	Stock (upper):	x 1.05
	Stock (lower):	x 0.95
	Arisings (upper):	x
	Arisings (lower):	x

**WASTE SOURCE** The waste arises from floc decontamination of low level liquors at Harwell.

**PHYSICAL CHARACTERISTICS**

General description: Comprises of low level slurry which will be in-drum cemented. Dried slurry is a solid containing mainly hydrated ferric hydroxide typically contaminated with Cs, Sr, Co and U. Slurry is generated by floc precipitation to decontaminate aqueous low level waste from buildings at Harwell. There are no large items present in this waste stream.

Physical components (%wt): On average: ~ 14% solids ~ 86% water

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): ~1

Comment on density: Raw bulk density ~ 1 t/m<sup>3</sup> with the conditioned density = 1.26 t/m<sup>3</sup> (when encapsulated)

**CHEMICAL COMPOSITION**

General description and components (%wt): Dry ferric hydroxide solids (14%) and water (86%).

Chemical state: Alkali

Chemical form of radionuclides: H-3: Tritium is associated with ferric hydroxide.  
 Ra: Basic radium salts are associated with ferric hydroxide.  
 Th: Basic thorium salts are associated with ferric hydroxide.  
 U: Basic uranium salts are associated with ferric hydroxide.  
 Pu: Basic plutonium salts are associated with ferric hydroxide.

Metals and alloys (%wt): -

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

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

Organics (%wt): Only trace amounts of organic material 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	TR		

Other materials (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials	0		
Inorganic sludges and flocs	14.0	Dry ferric hydroxide solids	
Soil	0		
Brick/Stone/Rubble	0		
Cementitious material	0		
Sand			
Glass/Ceramics	0		
Graphite	0		
Desiccants/Catalysts			
Asbestos	0		
Non/low friable			
Moderately friable			
Highly friable			
Free aqueous liquids	86.0		

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Free non-aqueous liquids..... 0

Powder/Ash..... 0

Inorganic anions (%wt): No inorganic anions are present in significant quantities apart from hydroxides and carbonates.

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

Materials of interest for waste acceptance criteria: Trace levels of toxic metals possibly present, but not at levels that make the waste hazardous. Free liquid will not present any non-radiological hazards after the sludge is encapsulated in cement.

	(%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: -

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

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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):      Yes

	(%wt)	Type(s) and comment
EDTA.....		Low, possibly amine polycarboxylic acids (e.g. EDTA) and oxalates
DPTA.....		
NTA.....		
Polycarboxylic acids.....		
Other organic complexants.....		
Total complexing agents.....	NE	

Potential for the waste to contain discrete items:      No. In & of itself not a DI; assumed not likely to contain any "rogue" items that could be.

**TREATMENT, PACKAGING AND DISPOSAL**

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Planned on-site / off-site treatment(s):

Treatment	On-site / Off site	Stream volume %
Low force compaction Supercompaction (HFC) Incineration Solidification Decontamination Metal treatment Size reduction Decay storage Recycling / reuse Other / various None	On-site	100.0

Comment on planned treatments:

waste will be solidified into 227 litre drums prior to consignment in a HHISO to LLWR

**Disposal Routes:**

Disposal Route	Stream volume %	Disposal density t/m3
Expected to be consigned to the LLW Repository Expected to be consigned to a Landfill Facility Expected to be consigned to an On-Site Disposal Facility Expected to be consigned to an Incineration Facility Expected to be consigned to a Metal Treatment Facility Expected to be consigned as Out of Scope Expected to be recycled / reused Disposal route not known	100.0	1.3

Classification codes for waste expected to be consigned to a landfill facility: -

**Upcoming (2022/23-2024/25) Waste Routing (if expected to change from above):**

Disposal Route	Stream volume %		
	2022/23	2023/24	2024/25
Expected to be consigned to the LLW Repository Expected to be consigned to a Landfill Facility Expected to be consigned to an On-Site Disposal Facility Expected to be consigned to an Incineration Facility Expected to be consigned to a Metal Treatment Facility Expected to be consigned as Out of Scope Expected to be recycled / reused Disposal route not known			

**Opportunities for alternative disposal routing:** -

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

**Waste Packaging for Disposal:**

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Container	Stream volume %	Waste loading m <sup>3</sup>	Number of packages
1/3 Height IP-1 ISO 2/3 Height IP-2 ISO 1/2 Height WAMAC IP-2 ISO 1/2 Height IP-2 Disposal/Re-usable ISO 2m box (no shielding) 4m box (no shielding) Other	100.0	3.6	3

Other information:                      The primary waste containment will be a 227-litre mild steel drum. There will be 36 drums per HHISO.

**Waste Planned for Disposal at the LLW Repository:**

Container voidage:                      Voidage <<10%

Waste Characterisation Form (WCH):                      The waste meets the LLWR's Waste Acceptance Criteria (WAC).  
The waste does not have a current WCH.

Waste consigned for disposal to LLWR in year of generation:                      No. Waste will be retrieved and solidified in a single campaign.

**Non-Containerised Waste for In-Vault Grouting:**      (Not applicable to this waste stream)

Stream volume (%):                      -

Waste stream variation:                      -

Bounding cuboidal volume:

Inaccessible voidage:                      -

Other information:                      -

**RADIOACTIVITY**

Source:                                      Contamination of liquid effluents from a range of activities/sources used on the Harwell site.

Uncertainty:                                Good analytical data based on modern analytical techniques and equipment, but composition of arisings will vary with nature of work generating the sludge.

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:                      Laboratory analysis.

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	1.27E-05	BB 2			Gd 153		8		
Be 10		8			Ho 163		8		
C 14		8			Ho 166m		8		
Na 22		8			Tm 170		8		
Al 26		8			Tm 171		8		
Cl 36		8			Lu 174		8		
Ar 39		8			Lu 176		8		
Ar 42		8			Hf 178n		8		
K 40		8			Hf 182		8		
Ca 41		8			Pt 193		8		
Mn 53		8			Tl 204		8		
Mn 54		8			Pb 205		8		
Fe 55		8			Pb 210	9.77E-06	BB 2		
Co 60	1.05E-05	BB 2			Bi 208		8		
Ni 59		8			Bi 210m		8		
Ni 63		8			Po 210	9.49E-06	BB 2		
Zn 65		8			Ra 223		8		
Se 79		8			Ra 225		8		
Kr 81		8			Ra 226	2.65E-05	BB 2		
Kr 85		8			Ra 228	4.47E-06	BB 2		
Rb 87		8			Ac 227		8		
Sr 90	4.86E-03	BB 2			Th 227		8		
Zr 93		8			Th 228	4.04E-06	BB 2		
Nb 91		8			Th 229		8		
Nb 92		8			Th 230		8		
Nb 93m		8			Th 232	5.34E-06	BB 2		
Nb 94		8			Th 234	1.97E-04	BB 2		
Mo 93		8			Pa 231		8		
Tc 97		8			Pa 233	8.26E-09	BB 2		
Tc 99		8			U 232		8		
Ru 106		8			U 233		8		
Pd 107		8			U 234	1.13E-08	BB 2		
Ag 108m		8			U 235	1.58E-06	BB 2		
Ag 110m		8			U 236		8		
Cd 109		8			U 238	1.97E-04	BB 2		
Cd 113m		8			Np 237	8.32E-09	BB 2		
Sn 119m		8			Pu 236		8		
Sn 121m		8			Pu 238	6.78E-05	BB 2		
Sn 123		8			Pu 239	4.91E-05	BB 2		
Sn 126		8			Pu 240	1.4E-04	BB 2		
Sb 125		8			Pu 241	1.45E-03	BB 2		
Sb 126		8			Pu 242		8		
Te 125m		8			Am 241	1.72E-03	BB 2		
Te 127m		8			Am 242m		8		
I 129		8			Am 243		8		
Cs 134	1.63E-06	BB 2			Cm 242		8		
Cs 135		8			Cm 243		8		
Cs 137	5.34E-03	BB 2			Cm 244	2.24E-05	BB 2		
Ba 133		8			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		8			Other a				
Eu 152		8			Other b/g				
Eu 154		8			<b>Total a</b>	<b>2.24E-03</b>	<b>BB 2</b>	<b>0</b>	
Eu 155		8			<b>Total b/g</b>	<b>1.19E-02</b>	<b>BB 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