

<b>WASTE STREAM</b>	<b>5C307</b>	<b>PLUTO Reactor Decommissioning LLW</b>
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**SITE** Harwell  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Magnox Limited  
**WASTE TYPE** LLW

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2019.....	0 m <sup>3</sup>
Future arisings -	1.4.2022 - 31.3.2025.....	262.0 m <sup>3</sup>
Total future arisings:		262.0 m <sup>3</sup>
Total waste volume:		262.0 m <sup>3</sup>

Comment on volumes: Volumes updated for 2016 RWI to reflect SMART Inventory Review

Uncertainty factors on volumes:  
 Stock (upper): x Arisings (upper) x 1.3  
 Stock (lower): x Arisings (lower) x 0.7

**WASTE SOURCE** Decommissioning of a 26MW(T) reactor in steel containment building with heavy water moderator.

**PHYSICAL CHARACTERISTICS**

General description: Contaminated steels and concrete from reactor and reactor storage blocks. Barytes concrete, lead fill and secondary waste. There are no large items in the waste.

Physical components (%vol): Biological shield (77%), care and maintenance waste (21%), lead (<2%) and steel and boral (<0.2%)

Sealed sources: -

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

Comment on density: Average density of barytes concrete (3.4t/m<sup>3</sup>), lead (11.3 t/m<sup>3</sup>), steel (7.8 t/m<sup>3</sup>), boral (2.7 t/m<sup>3</sup>) and care and maintenance waste (0.81 t/m<sup>3</sup>).

**CHEMICAL COMPOSITION**

General description and components (%wt): The biological shield and the waste from the care and maintenance will dominate the chemical composition of the waste. 94% metals, steel and concrete, 6% soft organics.

Chemical state: Neutral

Chemical form of radionuclides:  
 H-3: Tritium is present as an activation product in the graphite and concrete.  
 C-14: C-14 is present as an activation product in the graphite and concrete.  
 Cl-36: Cl-36 is present as an activation product in the biological shield.

Metals and alloys (%wt): -

Stainless steel.....	<1.0
Other ferrous metals.....	NE
Iron.....	
Aluminium.....	NE
Beryllium.....	
Cobalt.....	
Copper.....	NE
Lead.....	~7.0
Magnox/Magnesium.....	NE
Nickel.....	
Titanium.....	
Uranium.....	
Zinc.....	NE
Zircaloy/Zirconium.....	NE

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	Other metals.....	NE	
Organics (%wt):	-		
	Total cellulose.....	~~1.0	
	Paper, cotton.....	~~1.0	
	Wood.....	NE	
	Halogenated plastics .....	~~1.0	
	Total non-halogenated plastics.....	~~2.0	
	Condensation polymers.....	NE	
	Others.....	~~2.0	
	Organic ion exchange materials....	NE	
	Total rubber.....	~~1.0	
	Halogenated rubber .....	~~1.0	
	Non-halogenated rubber.....	NE	
	Hydrocarbons.....		
	Oil or grease .....		
	Fuel.....		
	Asphalt/Tarmac (cont.coal tar)...		
	Asphalt/Tarmac (no coal tar).....		
	Bitumen.....		
	Others.....		
	Other organics.....	P	
Other materials (%wt):	-		
	Inorganic ion exchange materials.	NE	
	Inorganic sludges and flocs.....	NE	
	Soil.....	P	
	Brick/Stone/Rubble.....	P	
	Cementitious material.....	~86.0	Barytes concrete
	Sand.....		
	Glass/Ceramics.....	NE	
	Graphite.....	NE	
	Desiccants/Catalysts.....		
	Asbestos.....	<1.0	
	Non/low friable.....		
	Moderately friable.....		
	Highly friable.....		
	Free aqueous liquids.....	0	
	Free non-aqueous liquids.....	0	
	Powder/Ash.....	P	
Inorganic anions (%wt):	-		

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Fluoride.....	NE
Chloride.....	NE
Iodide.....	NE
Cyanide.....	NE
Carbonate.....	NE
Nitrate.....	NE
Nitrite.....	NE
Phosphate.....	NE
Sulphate.....	NE
Sulphide.....	NE

Materials of interest for waste acceptance criteria:

Asbestos (<1%) and Lead (<6.5%). Concrete dust will arise from bioshield decommissioning.

Combustible metals.....	0
Low flash point liquids.....	0
Explosive materials.....	0
Phosphorus.....	0
Hydrides.....	0
Biological etc. materials.....	0
Biodegradable materials.....	
Putrescible wastes.....	0
Non-putrescible wastes.....	
Corrosive materials.....	0
Pyrophoric materials.....	0
Generating toxic gases.....	0
Reacting with water.....	0
Active particles.....	
Soluble solids as bulk chemical compounds.....	

Hazardous substances / non hazardous pollutants:

-	
Acrylamide.....	
Benzene.....	
Chlorinated solvents.....	
Formaldehyde.....	
Organometallics.....	
Phenol.....	
Styrene.....	
Tri-butyl phosphate.....	
Other organophosphates.....	
Vinyl chloride.....	
Arsenic.....	
Barium.....	
Boron.....	

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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):

EDTA.....  
 DPTA.....  
 NTA.....  
 Polycarboxylic acids.....  
 Other organic complexants.....  
 Total complexing agents..... NE

**TREATMENT, PACKAGING AND DISPOSAL**

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

Treatment	On-site / Off site	Stream volume %
Low force compaction	Off-site	~19.0
Supercompaction (HFC)		
Incineration		
Solidification		
Decontamination		
Metal treatment		
Size reduction		
Decay storage		
Recycling / reuse		
Other / various		
None		~81.0

Comment on planned treatments:

-

**WASTE STREAM****5C307****PLUTO Reactor Decommissioning LLW****Disposal Routes:**

Disposal Route	Stream volume %
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

**Upcoming (2019/20-2021/22) Waste Routing (if expected to change from above):**

Disposal Route	Stream volume %		
	2019/20	2020/21	2021/22
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			

**Waste Packaging for Disposal:**

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	~19.0 ~81.0	21.6 10	3 22

## Other information:

21.6m<sup>3</sup> loading volume is calculated based on the fact that you can fit 36 off (200 litre/0.2m<sup>3</sup>) drums (7.2m<sup>3</sup>) into a ½ height ISO, each drum can be super-compacted to a 1/3 of its original volume so therefore we can get 3 x the amount of un-compacted drums into the final disposal container (21.6m<sup>3</sup>).

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

Container voidage: -

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:

Yes.

Potential for the waste to contain discrete items:

-

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

Stream volume (%): -

Waste stream variation: -

Bounding cuboidal volume:

Inaccessible voidage:

Inaccessible voidage will be &lt;10%.

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Other information:

-

**RADIOACTIVITY**

Source:

Principally activation of reactor components.

Uncertainty:

-

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:

Specific activity for the future arising was calculated based on the original radioactive inventory for the structural components of Pluto and on the known operational history and the flux rates of the reactors. This inventory has been improved and corrected to include the structural materials.

Other information:

-

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Nuclide	Mean radioactivity, TBq/m <sup>3</sup>				Nuclide	Mean radioactivity, TBq/m <sup>3</sup>			
	Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code
H 3			8.03E-03	C C 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			2.3E-07	C C 2	Lu 174				8
Ar 39				8	Lu 176				8
Ar 42				8	Hf 178n				8
K 40				8	Hf 182				8
Ca 41			5.59E-06	C C 2	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55			4.47E-03	C C 2	Pb 210				8
Co 60			2.31E-03	C C 2	Bi 208				8
Ni 59			7.68E-05	C C 2	Bi 210m				8
Ni 63			8.36E-03	C C 2	Po 210				8
Zn 65				8	Ra 223				8
Se 79				8	Ra 225				8
Kr 81				8	Ra 226				8
Kr 85				8	Ra 228				8
Rb 87				8	Ac 227				8
Sr 90				8	Th 227				8
Zr 93				8	Th 228				8
Nb 91				8	Th 229				8
Nb 92				8	Th 230				8
Nb 93m				8	Th 232				8
Nb 94				8	Th 234				8
Mo 93				8	Pa 231				8
Tc 97				8	Pa 233				8
Tc 99				8	U 232				8
Ru 106				8	U 233				8
Pd 107				8	U 234				8
Ag 108m				8	U 235				8
Ag 110m				8	U 236				8
Cd 109				8	U 238				8
Cd 113m				8	Np 237				8
Sn 119m				8	Pu 236				8
Sn 121m				8	Pu 238				8
Sn 123				8	Pu 239				8
Sn 126				8	Pu 240				8
Sb 125				8	Pu 241				8
Sb 126				8	Pu 242				8
Te 125m				8	Am 241				8
Te 127m				8	Am 242m				8
I 129				8	Am 243				8
Cs 134				8	Cm 242				8
Cs 135				8	Cm 243				8
Cs 137				8	Cm 244				8
Ba 133			4.84E-04	C C 2	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			1.7E-08	C C 2	Other a				
Eu 152			3.7E-04	C C 2	Other b/g				
Eu 154			2.89E-05	C C 2	<b>Total a</b>	<b>0</b>		<b>0</b>	
Eu 155				8	<b>Total b/g</b>	<b>0</b>		<b>2.41E-02</b>	<b>C C 2</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