WASTE STREAM 5C307 PLUTO Reactor Decommissioning LLW

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.....	0 m³
Future arisings -	1.4.2040 - 31.3.2054.....	262.0 m³
Total future arisings:		262.0 m³
Total waste volume:		262.0 m³

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:	The waste does not contain sealed sources.
Bulk density (t/m³):	~3
Comment on density:	Average density of barytes concrete (3.4t/m³), lead (11.3 t/m³), steel (7.8 t/m³), boral (2.7 t/m³) and care and maintenance waste (0.81 t/m³).

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):	-

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	<1.0		
Other ferrous metals.....	NE		
Iron.....			
Aluminium.....	NE		
Beryllium.....			
Cobalt.....			
Copper.....	NE		
Lead.....	~7.0		
Magnox/Magnesium.....	NE		
Nickel.....			
Titanium.....			

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Uranium	
Zinc	NE
Zircaloy/Zirconium	NE
Other metals	NE

Organics (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics	~~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): -

	(%wt)	Type(s) and comment	% of total C14 activity
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	<1.0		
Free aqueous liquids	0		

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Free non-aqueous liquids.....	0
Powder/Ash.....	P

Inorganic anions (%wt): -

	(%wt)	Type(s) and comment
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.

	(%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.....		
Phenol.....		

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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):

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids…….		
Other organic complexants.....		
Total complexing agents.....	NE	

Potential for the waste to contain discrete items:	Yes. Large Concrete Items (LCIs) may be DIs; drummed (ungrouted)/"rubbleised" wastes assumed not DIs. Note - LCIs with embedded metals may also be DIs within DIs, depends on specific circumstances/waste form.Large Metal Items (LMIs)/"substantial" thickness items considered "durable" assumed DIs; Stainless items assumed DIs

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)	Off-site	~19.0
Incineration		
Solidification		
Decontamination		
Metal treatment		
Size reduction		
Decay storage		
Recyling / reuse		
Other / various		
None		~81.0

Comment on planned treatments: -

Disposal Routes:

Disposal Route	Stream volume %	Disposal density t/m3
Expected to be consigned to the LLW Repository	100.0	3.0
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		

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 m³	Number of packages
1/3 Height IP-1 ISO			
2/3 Height IP-2 ISO			
1/2 Height WAMAC IP-2 ISO	~19.0	21.6	3
1/2 Height IP-2 Disposal/Re-usable ISO	~81.0	10	22
2m box (no shielding)			
4m box (no shielding)			
Other			

Other information: 21.6m3 loading volume is calculated based on the fact that you can fit 36 off (200 litre/0.2m3) drums (7.2m3) 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 (21.6m3)

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.

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: 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/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			2.92E-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			4.67E-05	C C 2	Pb 210				8
Co 60			2.17E-04	C C 2	Bi 208				8
Ni 59			7.68E-05	C C 2	Bi 210m				8
Ni 63			7.37E-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			1.49E-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			1.48E-08	C C 2	Other a				
Eu 152			1.47E-04	C C 2	Other b/g				
Eu 154			6.77E-06	C C 2	**Total a**	**0**		**0**	
Eu 155				8	**Total b/g**	**0**		**1.09E-02**	**C C 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