WASTE STREAM 9A321 Graphite ILW

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

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	0 m^3
Future arisings -	1.4.2074 - 31.3.2077.....	3121.0 m^3
Total future arisings:		3121.0 m^3
Total waste volume:		3121.0 m^3

Comment on volumes: This waste stream describes the graphite that is now identified as ILW. Waste arisings are assumed to occur at a uniform rate over 3 years. Final Dismantling & Site Clearance is assumed to commence in 2070 with reactor dismantling commencing in 2074 and lasting for 3 years. Volumes and radioactivity have been calculated for 85 years after reactor shutdown, i.e. 2074.

Uncertainty factors on volumes:

Stock (upper):	x	Arisings (upper)	x 1.2
Stock (lower):	x	Arisings (lower)	x 0.8

WASTE SOURCE Moderator and reflector graphite from reactor dismantling.

PHYSICAL CHARACTERISTICS

General description: Graphite blocks and other graphite components. Waste can be packaged in standard ILW packages.

Physical components (%vol): Graphite (100%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m^3): ~1.25

Comment on density: The density is of the waste as cut for packaging. Density estimate based upon assumed packing efficiency of the waste with 90% of the graphite in blocks and 10% as rubble.

CHEMICAL COMPOSITION

General description and components (%wt): Graphite and possibly traces of ferrous metals.

Chemical state: Neutral

Chemical form of radionuclides:
H-3: Tritium may be chemically bound with the graphite.
C-14: The carbon 14 will be present as graphite.
Cl-36: The chlorine 36 will probably be chemically bound to the graphite. Some may be linked chemically with impurities in the graphite.
U: There may be traces of uranium as metal or oxide.
Pu: There may be traces of plutonium as metal or oxide.

Metals and alloys (%wt): There are no metallic items present.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	TR		
Other ferrous metals.....	TR	There may be trace contamination by ferrous metals.	
Iron.....			
Aluminium.....	0		
Beryllium.....	TR		
Cobalt.....			
Copper.....	0		

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Lead	0	
Magnox/Magnesium	0	
Nickel		
Titanium		
Uranium		
Zinc	0	
Zircaloy/Zirconium	0	
Other metals	0	There are no "other" metals present.

Organics (%wt): None expected. Halogenated plastics or rubbers will not be present.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics	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	0		

Other materials (%wt): Expect only graphite.

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials	0		
Inorganic sludges and flocs	0		
Soil	0		
Brick/Stone/Rubble	0		
Cementitious material	0		
Sand			
Glass/Ceramics	0		
Graphite	100.0		100.0
Desiccants/Catalysts			
Asbestos	0		

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Non/low friable.....	
Moderately friable.....	
Highly friable.....	
Free aqueous liquids.....	0
Free non-aqueous liquids.....	0
Powder/Ash.....	0

Inorganic anions (%wt): None of the inorganic anions listed in the table is expected to be present at greater than trace concentrations.

	(%wt)	Type(s) and comment
Fluoride.....	TR	Detected at trace levels in inactive graphite material.
Chloride.....	TR	
Iodide.....	0	
Cyanide.....	0	
Carbonate.....	TR	
Nitrate.....	TR	
Nitrite.....	0	
Phosphate.....	TR	Detected at trace levels in inactive graphite material.
Sulphate.....	TR	Detected at trace levels in inactive graphite material.
Sulphide.....	0	

Materials of interest for waste acceptance criteria: No materials likely to pose a fire or other non-radiological hazard have been identified. Graphite presents a low fire risk; it is difficult but not impossible to ignite.

	(%wt)	Type(s) and comment
Combustible metals.....	0	
Low flash point liquids.....	0	
Explosive materials.....	0	
Phosphorus.....	TR	Detected at trace levels in inactive graphite material.
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	
Higher activity particles.....		
Soluble solids as bulk chemical compounds.....		

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Hazardous substances / non hazardous pollutants: None expected

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....		
Chlorinated solvents.....		
Formaldehyde.....		
Organometallics.....		
Phenol.....		
Styrene.....		
Tri-butyl phosphate.....		
Other organophosphates.....		
Vinyl chloride.....		
Arsenic.....	TR	Detected at trace levels in inactive graphite material.
Barium.....		
Boron.....		
Boron (in Boral).....		
Boron (non-Boral).....		
Cadmium.....		
Caesium.....		
Selenium.....		
Chromium.....		
Molybdenum.....		
Thallium.....	TR	Detected at trace levels in inactive graphite material.
Tin.....		
Vanadium.....		
Mercury compounds.....		
Others.....	TR	Gallium, germanium and rubidium detected at trace levels in inactive graphite material.
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.....		
DPTA.....		
NTA.....		
Polycarboxylic acids…….		
Other organic complexants.....		

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Total complexing agents..... TR

Potential for the waste to contain discrete items: Yes. Graphite Bricks/Tiles assumed to be DIs. Bricks assumed drummed (ungrouted) so assumed Bricks are DIs; IF grouted, drum is also a DI. "Rubble" pieces assumed drummed (ungrouted) assumed NOT DIs; IF grouted, drum is a DI.

PACKAGING AND CONDITIONING

Conditioning method: The waste is not expected to be supercompacted. It will be placed in baskets in the waste packages followed by conditioning with BFS/OPC.

Plant Name: None

Location: Berkeley Site

Plant startup date: 2074

Total capacity (m³/y incoming waste): ~5000.0

Target start date for packaging this stream: 2074

Throughput for this stream (m³/y incoming waste): ~780.0

Other information: It is currently intended that FSC wastes will be grouted.

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m³)	Payload (m³)	Number of packages
4m box (no shielding)	100.0	16.2	18.9	193

Likely container type comment: The waste is assumed to be in baskets in the waste package so the occupied volume in the package is greater than the original waste volume. Container choice may be influenced by Transport Regulations at the time of Final Site Clearance.

Range in container waste volume: Not yet determined. No significant variability is expected.

Other information on containers: The container material is expected to be stainless steel.

Likely conditioning matrix: Blast Furnace Slag / Ordinary Portland Cement

Other information: -

Conditioned density (t/m³): ~1.7

Conditioned density comment: The conditioned waste density assumes the waste will be encapsulated.

Other information on conditioning: The waste will be in baskets placed in the waste packages. Baskets of different Final Dismantling & Site Clearance ILW wastes may be in the same waste package. As encapsulation is now intended, the matrix would be likely to be BFS/OPC and the density of the conditioned waste product would be about 1.7 t/m3.

Opportunities for alternative disposal routing: -

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

RADIOACTIVITY

Source: Activation of graphite and impurities.

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Uncertainty:	The values quoted were derived by calculation from available material specification and are indicative of the activities that are expected. The major source of uncertainty is the impurity levels.
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:	The specific activities have been estimated using a neutron activation calculation. With additional data from newly calculated inventories including 100 ppb U precursor as per M/EF/GEN/EAN/0008/20
Other information:	There may be some contamination by Cs137. The activities quoted are those at 85 years after reactor shutdown, i.e. in 2074. Fission of trace uranium impurity in the graphite may result in some fission product and actinide activity.

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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			6.09E-03	C C 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			7.67E-02	B B 2	Ho 166m			4.92E-07	C C 2
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			2.01E-04	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			2.02E-04	C C 2	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55				8	Pb 210				8
Co 60			6.42E-07	C C 2	Bi 208				8
Ni 59			2.6E-05	C C 2	Bi 210m				8
Ni 63			1.85E-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			6.63E-07	C C 2	Ra 228				8
Rb 87				8	Ac 227				8
Sr 90			1.64E-04	C C 2	Th 227				8
Zr 93			3.97E-08	C C 2	Th 228				8
Nb 91				8	Th 229				8
Nb 92				8	Th 230				8
Nb 93m			3.81E-08	C C 2	Th 232				8
Nb 94			1.68E-07	C C 2	Th 234			1.07E-09	C C 2
Mo 93				8	Pa 231				8
Tc 97				8	Pa 233			1.64E-09	C C 2
Tc 99			3.15E-07	C C 2	U 232				8
Ru 106				8	U 233				8
Pd 107			3.56E-09	C C 2	U 234			1.1E-08	C C 2
Ag 108m			3.47E-07	C C 2	U 235				8
Ag 110m				8	U 236				8
Cd 109				8	U 238			1.07E-09	C C 2
Cd 113m				8	Np 237			1.65E-09	C C 2
Sn 119m				8	Pu 236				8
Sn 121m			1.15E-04	C C 2	Pu 238			2.8E-05	C C 2
Sn 123				8	Pu 239			2.87E-06	C C 2
Sn 126			1.37E-08	C C 2	Pu 240			1.07E-05	C C 2
Sb 125				8	Pu 241			2.9E-05	C C 2
Sb 126			1.92E-09	C C 2	Pu 242			2.28E-07	C C 2
Te 125m				8	Am 241			5.54E-05	C C 2
Te 127m				8	Am 242m			7.75E-08	C C 2
I 129				8	Am 243			4.36E-06	C C 2
Cs 134				8	Cm 242			6.41E-08	C C 2
Cs 135			1.12E-08	C C 2	Cm 243			7.79E-08	C C 2
Cs 137			3.13E-04	C C 2	Cm 244			6.06E-05	C C 2
Ba 133			5.42E-07	C C 2	Cm 245			1.13E-07	C C 2
La 137				8	Cm 246			2.1E-07	C C 2
La 138				8	Cm 248				8
Ce 144				8	Cf 249				8
Pm 145			5.3E-08	C C 2	Cf 250				8
Pm 147				8	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151			2.39E-06	C C 2	Other a				
Eu 152			1.33E-07	C C 2	Other b/g				
Eu 154			5.23E-07	C C 2	**Total a**	**0**		**1.63E-04**	**C C 2**
Eu 155			1.59E-09	C C 2	**Total b/g**	**0**		**8.57E-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