WASTE STREAM 9A316 Graphite LLW

SITE Berkeley

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Magnox Limited

WASTE TYPE LLW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	0 m³
Future arisings -	1.4.2074 - 31.3.2077.....	33.0 m³
Total future arisings:		33.0 m³
Total waste volume:		33.0 m³

Comment on volumes: Some waste previously identified as LLW is now identified as ILW. Waste arisings are assumed to occur at a uniform rate over 5 years. Final Dismantling & Site Clearance is assumed to commence in 2070 with reactor dismantling commencing in 2074 and lasting for 3 years. The 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 Gas deflector and thermal column graphite from reactor dismantling.

PHYSICAL CHARACTERISTICS

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

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

Sealed sources: -

Bulk density (t/m³): ~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.

Stainless steel.....	TR	There may be trace contamination by ferrous metals.
Other ferrous metals.....	TR	There may be trace contamination by ferrous metals.
Iron.....		
Aluminium.....	0	
Beryllium.....	TR	
Cobalt.....		
Copper.....	0	
Lead.....	0	
Magnox/Magnesium.....	0	
Nickel.....		

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

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

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.

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	
Active particles		
Soluble solids as bulk chemical compounds		

Hazardous substances / non hazardous pollutants: None expected.

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.....		
Cadmium.....		
Caesium.....		
Selenium.....		
Chromium.....		
Molybdenum.....		
Thallium.....	TR	Detected at trace levels in inactive graphite material.
Tin.....		
Vanadium.....		
Mercury compounds.....		
Others.....	TR	
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.....	TR

TREATMENT, PACKAGING AND DISPOSAL

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 Recyling / reuse Other / various None		100.0

Comment on planned treatments:

It is envisaged that the waste will be put into baskets, placed in the container and grouted . Different Final Dismantling and Site Clearance LLW may be placed in the same package. The occupied volume in the package is greater than the original waste volume. A conditioning factor of 1.167 has been assumed to allow for the waste being placed in baskets before loading into standard 4m boxes.

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Disposal Routes:

Disposal Route	Stream volume %
Expected to be consigned to the LLW Repository	100.0
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	

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 m³	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)	100.0	16.2	3
Other			

Other information: It is likely that this waste will be placed in a container with other LLW. The type of container to be used is under review.

Waste Planned for Disposal at the LLW Repository:

Container voidage: In-accessible voidage is not expected.

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. The timing of consignment of the waste for disposal cannot be determined at present.

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: -

Other information: -

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RADIOACTIVITY

Source:	Activation of the graphite and impurities.
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:	Total beta/gamma is defined as the sum of the listed activities of all nuclides other than alpha emitters. Activity estimates for individual alpha emitting nuclides have not been provided.
Measurement of radioactivities:	The specific activities have been estimated using a neutron activation calculation.
Other information:	The activities quoted are those at 85 years after reactor shutdown, i.e. in 2074. There may be some contamination by Cs137. 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 1.4.2019	Bands and Code	Future arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code
H 3			8.07E-04	C C 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			1.08E-03	C C 2	Ho 166m			5.4E-09	C C 2
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			3.74E-06	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			3.14E-06	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			1.14E-08	C C 2	Bi 208				8
Ni 59			5.39E-07	C C 2	Bi 210m				8
Ni 63			3.25E-05	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				6	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			2.1E-09	C D 2	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			4.6E-09	C C 2	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			1.79E-07	C C 2	Pu 238				6
Sn 123				8	Pu 239				6
Sn 126				8	Pu 240				6
Sb 125				8	Pu 241				8
Sb 126				8	Pu 242				8
Te 125m				8	Am 241				6
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				6	Cm 244				8
Ba 133			9.06E-09	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			3.18E-07	C C 2	Other a				
Eu 152			4.05E-06	C C 2	Other b/g				
Eu 154			7.05E-08	C C 2	**Total a**	**0**		**0**	
Eu 155				8	**Total b/g**	**0**		**1.93E-03**	**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