WASTE STREAM 2D02 High Level Liquid Waste

SITE Sellafield

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Sellafield Limited

WASTE TYPE HLW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	1236.1 m³
Future arisings -	1.4.2019 - 31.3.2020.....	0 m³
	1.4.2020 - 31.3.2021.....	-137.0 m³
	1.4.2021 - 31.3.2022.....	-32.9 m³
	1.4.2022 - 31.3.2023.....	-60.5 m³
	1.4.2023 - 31.3.2024.....	-49.1 m³
	1.4.2024 - 31.3.2025.....	41.8 m³
	1.4.2025 - 31.3.2026.....	-173.9 m³
	1.4.2026 - 31.3.2027.....	-173.9 m³
	1.4.2027 - 31.3.2028.....	-135.7 m³
	1.4.2028 - 31.3.2029.....	-135.2 m³
	1.4.2029 - 31.3.2030.....	0 m³
Total future arisings:		-856.3 m³
Total waste volume:		379.8 m³

Comment on volumes: Arisings are based on the HA Liquor from Magnox, POCO washings and planned transfers to the Waste Vitrification Plants resulting in a net decrease in stocks over time. The remaining waste volume is from liquor heels in the HASTs which will not be removed until after POCO operations. The route for this removal has not been confirmed. Waste volumes are derived based on planned fuel reprocessing programmes for Thorp and Magnox plants and assumed waste liquor storage concentrations. These concentrations are comparable with historical storage concentrations and as such are expected to be reasonably representative. Uncertainties in arising and processing rates along with stored liquor dilution variability support an estimated uncertainty range of +/- 1.5 at this time.

Uncertainty factors on volumes:

Stock (upper):	x 1.1	Arisings (upper)	x 1.5
Stock (lower):	x 0.9	Arisings (lower)	x 0.67

WASTE SOURCE Concentrated fission product solution from the first stage of primary separation in reprocessing plants.

PHYSICAL CHARACTERISTICS

General description: The waste is a nitric acid solution containing fission products, some actinides and some solids. There are no large items which require special handling.

Physical components (%vol): Liquid (100%) with some suspended solids.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 1.28

Comment on density: The average material density of the waste is 1.28 t/m³.

CHEMICAL COMPOSITION

General description and components (%wt): Nitric acid, fission product nitrates and oxides, corrosion products (iron, magnesium, chromium, nickel, aluminium), actinides and phosphates.

Chemical state: Acid

Chemical form of radionuclides:
H-3: Likely to be present as water.
C-14: Unknown - possibly present as traces of dissolved solvent.
Se-79: Present as nitrate.
Tc-99: Present as nitrate.
Ra: Likely to be present as nitrate.
Th: Present as nitrate.
U: Present as nitrate.
Np: Present as nitrate.
Pu: Present as nitrate.

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

WASTE STREAM 2D02 High Level Liquid Waste

	Stainless steel	0	
	Other ferrous metals	0	
	Iron	0	
	Aluminium		
	Beryllium	0	
	Cobalt	0	
	Copper		
	Lead	0	
	Magnox/Magnesium	0	
	Nickel	TR	Nickel will be present as corrosion product.
	Titanium		
	Uranium	0	
	Zinc	0	
	Zircaloy/Zirconium	0	
	Other metals	TR	Niobium will be present as corrosion product.
Organics (%wt):	The waste contains no organic materials, other than possible traces of complexing agents.		
	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	0	
	Oil or grease	0	
	Fuel	0	
	Asphalt/Tarmac (cont.coal tar)	0	
	Asphalt/Tarmac (no coal tar)	0	
	Bitumen	0	
	Others	0	
	Other organics	0	
Other materials (%wt):	Solids in the waste are suspended in the bulk liquor by agitation.		
	Inorganic ion exchange materials.	0	
	Inorganic sludges and flocs	0	
	Soil	0	
	Brick/Stone/Rubble	0	
	Cementitious material	0	
	Sand		

WASTE STREAM 2D02 High Level Liquid Waste

Glass/Ceramics	
Graphite	0
Desiccants/Catalysts	
Asbestos	0
Non/low friable	0
Moderately friable	0
Highly friable	0
Free aqueous liquids	0
Free non-aqueous liquids	100.0
Powder/Ash	0

Inorganic anions (%wt): The waste contains nitrates, phosphates, chlorides and trace quantities of oxides and sulphates. The waste also contains molybdates (not estimated).

Fluoride	0
Chloride	<0.10
Iodide	0
Cyanide	0
Carbonate	0
Nitrate	<50.0
Nitrite	NE
Phosphate	<0.25
Sulphate	TR
Sulphide	0

Materials of interest for waste acceptance criteria: The waste contains nitric acid which is a strong oxidising agent and can generate NOx gases.

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	15.0
Pyrophoric materials	0
Generating toxic gases	15.0
Reacting with water	0
Active particles	
Soluble solids as bulk chemical compounds	

Hazardous substances / non hazardous pollutants: The waste contains toxic fission products (<10% in total). Nitric acid.

Acrylamide	
Benzene	

WASTE STREAM 2D02 High Level Liquid Waste

	Chlorinated solvents.....	
	Formaldehyde.....	
	Organometallics.....	
	Phenol.....	
	Styrene.....	
	Tri-butyl phosphate.....	
	Other organophosphates.....	
	Vinyl chloride.....	
	Arsenic.....	
	Barium.....	
	Boron.....	
	Cadmium.....	
	Caesium.....	
	Selenium.....	
	Chromium.....	
	Molybdenum.....	
	Thallium.....	
	Tin.....	
	Vanadium.....	
	Mercury compounds.....	
	Others.....	
	Electronic Electrical Equipment (EEE)	
	EEE Type 1..... 0	
	EEE Type 2..... 0	
	EEE Type 3..... 0	
	EEE Type 4..... 0	
	EEE Type 5..... 0	
Complexing agents (%wt):	Yes	
	EDTA..... 0	
	DPTA..... 0	
	NTA..... 0	
	Polycarboxylic acids……	
	Other organic complexants.....	Organic complexing agents may be present at low concentrations.
	Total complexing agents..... TR	

PACKAGING AND CONDITIONING

Conditioning method:	The liquid will be vitrified.
Plant Name:	Waste Vitrification Plant
Location:	Sellafield
Plant startup date:	July 1990
Total capacity (m^3/y incoming waste):	~400.0
Target start date for packaging this stream:	-

WASTE STREAM 2D02 High Level Liquid Waste

Throughput for this stream (m³/y incoming waste): ~300.0

Other information: Initially intermediate age material will be vitrified as this is consistent with the aim to achieve optimum heat loadings per container, whilst meeting other constraints and objectives. Older material will be blended with higher heat content liquors.

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m³)	Payload (m³)	Number of packages
HLW canister	100.0	~0.41	0.15	927

Likely container type comment: 0.41m³ waste will result in 0.15m³ of conditioned waste in a HLW container with a displacement volume of 0.196m³. The average conditioning factor is 0.366 and the packaging factor is 0.478.

Range in container waste volume: -

Other information on containers: Stainless steel grade 309.

Likely conditioning matrix: Glass

Other information: Glass block within a stainless steel container.

Conditioned density (t/m³): 2.65

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: No

Treatment	Stream volume (%)	Comment
-	-	-

RADIOACTIVITY

Source: The main sources of activity in the waste are mixed fission products and actinides resulting from the reprocessing of irradiated Oxide and Magnox fuels.

Uncertainty: The activity accuracy is good. Based on tank and analytical records with activities derived using FISPIN based decay calculations.

Definition of total alpha and total beta/gamma: The total specific activity values given on the radionuclide table are the sum of the listed alpha or beta/gamma emitting radionuclides excluding "other alpha" and "other beta/gamma", which are not estimated.

Measurement of radioactivities: Specific activity data has been derived using calculated activities from tank and analytical records along with nuclear codes. The resultant activities have been divided by the measured waste volume to produce the specific activities reported.

Other information: Short-lived daughters are not included. Other radionuclides not listed represent less than 0.01% of the total activity.

WASTE STREAM 2D02 High Level Liquid Waste

Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	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	8.99E-02	D D 2	8.99E-02	D D 2	Gd 153	2.71E-05	A A 2	2.71E-05	A A 2
Be 10	3.34E-06	A A 2	3.34E-06	A A 2	Ho 163	8.13E-10	A A 2	8.13E-10	A A 2
C 14	2.92E-03	B B 2	2.92E-03	B B 2	Ho 166m	1.21E-05	A A 2	1.21E-05	A A 2
Na 22					Tm 170	2.14E-10	A A 2	2.14E-10	A A 2
Al 26					Tm 171	2.41E-04	A A 2	2.41E-04	A A 2
Cl 36	2.54E-04	C C 2	2.54E-04	C C 2	Lu 174		8		8
Ar 39		8		8	Lu 176		8		8
Ar 42		8		8	Hf 178n		8		8
K 40	7.09E-18	5	7.09E-18	5	Hf 182	1.94E-14	A A 2	1.94E-14	A A 2
Ca 41	9.54E-05	A A 8	9.54E-05	A A 8	Pt 193		8		8
Mn 53	1.17E-11	A A 2	1.17E-11	A A 2	Tl 204		8		8
Mn 54	9.76E-04	A A 2	9.76E-04	A A 2	Pb 205	3.20E-11	A A 2	3.20E-11	A A 2
Fe 55	7.57E-01	A A 2	7.57E-01	A A 2	Pb 210	2.38E-08	A A 2	2.38E-08	A A 2
Co 60	2.38E+00	A A 2	2.38E+00	A A 2	Bi 208		8		8
Ni 59	3.38E-04	A A 2	3.38E-04	A A 2	Bi 210m	1.36E-15	A A 8	1.36E-15	A A 8
Ni 63	3.75E-02	A A 2	3.75E-02	A A 2	Po 210	2.27E-08	A A 2	2.27E-08	A A 2
Zn 65	9.89E-07	A A 2	9.89E-07	A A 2	Ra 223	7.27E-07	A A 2	7.27E-07	A A 2
Se 79	2.90E-03	A A 2	2.90E-03	A A 2	Ra 225	7.69E-09	A A 2	7.69E-09	A A 2
Kr 81		8		8	Ra 226	8.48E-08	A A 2	8.48E-08	A A 2
Kr 85		8		8	Ra 228	6.90E-12	A A 2	6.90E-12	A A 2
Rb 87	1.19E-06	A A 2	1.19E-06	A A 2	Ac 227	7.30E-07	A A 2	7.30E-07	A A 2
Sr 90	2.56E+03	A A 2	2.56E+03	A A 2	Th 227	7.18E-07	A A 2	7.18E-07	A A 2
Zr 93	1.01E-01	A A 2	1.01E-01	A A 2	Th 228	5.41E-05	A A 2	5.41E-05	A A 2
Nb 91	4.16E-16	A A 2	4.16E-16	A A 2	Th 229	7.69E-09	A A 2	7.69E-09	A A 2
Nb 92	9.41E-14	A A 2	9.41E-14	A A 2	Th 230	1.11E-05	A A 2	1.11E-05	A A 2
Nb 93m	5.95E-02	A A 2	5.95E-02	A A 2	Th 232	8.64E-12	A A 2	8.64E-12	A A 2
Nb 94	4.77E-05	A A 2	4.77E-05	A A 2	Th 234	3.54E-06	A A 2	3.54E-06	A A 2
Mo 93	5.04E-05	A A 2	5.04E-05	A A 2	Pa 231	1.64E-06	A A 2	1.64E-06	A A 2
Tc 97	8.21E-13	A A 2	8.21E-13	A A 2	Pa 233	6.64E-03	A A 2	6.64E-03	A A 2
Tc 99	6.02E-01	A A 2	6.02E-01	A A 2	U 232	1.21E-07	A A 2	1.21E-07	A A 2
Ru 106	2.91E+01	A A 2	2.91E+01	A A 2	U 233	2.21E-07	A A 2	2.21E-07	A A 2
Pd 107	5.51E-03	A A 2	5.51E-03	A A 2	U 234	1.49E-05	A A 2	1.49E-05	A A 2
Ag 108m	2.14E-07	A A 2	2.14E-07	A A 2	U 235	1.46E-07	A A 2	1.46E-07	A A 2
Ag 110m	5.15E-03	A A 2	5.15E-03	A A 2	U 236	1.53E-06	A A 2	1.53E-06	A A 2
Cd 109	7.88E-08	A A 2	7.88E-08	A A 2	U 238	3.54E-06	A A 2	3.54E-06	A A 2
Cd 113m	2.64E-01	A A 2	2.64E-01	A A 2	Np 237	6.64E-03	A A 2	6.64E-03	A A 2
Sn 119m	4.23E-04	A A 2	4.23E-04	A A 2	Pu 236	3.00E-07	A A 2	3.00E-07	A A 2
Sn 121m	6.80E-01	A A 2	6.80E-01	A A 2	Pu 238	2.58E-01	A A 2	2.58E-01	A A 2
Sn 123	2.21E-05	A A 2	2.21E-05	A A 2	Pu 239	4.17E-02	A A 2	4.17E-02	A A 2
Sn 126	1.65E-02	A A 2	1.65E-02	A A 2	Pu 240	1.28E-01	A A 2	1.28E-01	A A 2
Sb 125	1.93E+01	A A 2	1.93E+01	A A 2	Pu 241	5.48E+00	A A 2	5.48E+00	A A 2
Sb 126	5.32E-03	A A 2	5.32E-03	A A 2	Pu 242	2.80E-04	A A 2	2.80E-04	A A 2
Te 125m	4.72E+00	A A 2	4.72E+00	A A 2	Am 241	5.95E+01	A A 2	5.95E+01	A A 2
Te 127m	1.19E-05	A A 2	1.19E-05	A A 2	Am 242m	1.95E-01	A A 2	1.95E-01	A A 2
I 129	1.51E-05	B B 2	1.51E-05	B B 2	Am 243	5.11E-01	A A 2	5.11E-01	A A 2
Cs 134	3.61E+01	A A 2	3.61E+01	A A 2	Cm 242	1.65E-01	A A 2	1.65E-01	A A 2
Cs 135	3.30E-02	A A 2	3.30E-02	A A 2	Cm 243	3.93E-01	A A 2	3.93E-01	A A 2
Cs 137	3.53E+03	A A 2	3.53E+03	A A 2	Cm 244	3.89E+01	A A 2	3.89E+01	A A 2
Ba 133	4.28E-08	A A 2	4.28E-08	A A 2	Cm 245	7.14E-03	A A 2	7.14E-03	A A 2
La 137	4.61E-08	A A 2	4.61E-08	A A 2	Cm 246	1.92E-03	A A 2	1.92E-03	A A 2
La 138	1.39E-12	A A 2	1.39E-12	A A 2	Cm 248	1.83E-08	A A 2	1.83E-08	A A 2
Ce 144	1.86E+01	A A 2	1.86E+01	A A 2	Cf 249	1.44E-07	A A 2	1.44E-07	A A 2
Pm 145	1.73E-05	A A 2	1.73E-05	A A 2	Cf 250	3.64E-07	A A 2	3.64E-07	A A 2
Pm 147	4.08E+02	A A 2	4.08E+02	A A 2	Cf 251	7.19E-09	A A 2	7.19E-09	A A 2
Sm 147	4.09E-07	A A 2	4.09E-07	A A 2	Cf 252	5.65E-09	A A 2	5.65E-09	A A 2
Sm 151	1.64E+01	A A 2	1.64E+01	A A 2	Other a		5		5
Eu 152	1.58E-01	A A 2	1.58E-01	A A 2	Other b/g		5		5
Eu 154	7.46E+01	A A 2	7.46E+01	A A 2	**Total a**	**9.99E+01**	**A A 2**	**9.99E+01**	**A A 2**
Eu 155	1.22E+01	A A 2	1.22E+01	A A 2	**Total b/g**	**6.72E+03**	**A A 2**	**6.72E+03**	**A A 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