WASTE STREAM	7G103	LLW from Decommissioned Submarines

SITE Rosyth & Devonport (Submarines)

SITE OWNER Ministry of Defence (MOD)

WASTE CUSTODIAN Babcock and Ministry of Defence

WASTE TYPE LLW

WASTE VOLUMES

		Reported (m^3)	OR	Conditioned (m^3)	Packaged (m^3)
Stocks:	At 1.4.2025	19.7			
Future arisings:	1.4.2025 - 31.3.2026	= 15.9			
	1.4.2026 - 31.3.2027	= 0			
	1.4.2027 - 31.3.2028	18.0			
	1.4.2028 - 31.3.2029	= 18.0			
	1.4.2029 - 31.3.2030	0			
	1.4.2030 - 31.3.2031	= 18.0			
	1.4.2031 - 31.3.2032	= 8.6			
	1.4.2032 - 31.3.2033	= 8.6			
	1.4.2033 - 31.3.2034	= 18.0			
	1.4.2034 - 31.3.2035	6.6			
	1.4.2035 - 31.3.2036	= 18.0			
	1.4.2036 - 31.3.2037	= 18.0			
	1.4.2037 - 31.3.2038	= 0			
	1.4.2038 - 31.3.2039	= 0			
	1.4.2039 - 31.3.2040	= 18.0			
	1.4.2040 - 31.3.2041	= 0			
	1.4.2041 - 31.3.2042	= 18.0			
	1.4.2042 - 31.3.2043	= 0			
	1.4.2043 - 31.3.2044	= 18.0			
	1.4.2044 - 31.3.2045	= 18.0			
	1.4.2045 - 31.3.2046	= 0			
	1.4.2046 - 31.3.2047	= 22.9			
	1.4.2047 - 31.3.2048	= 0			
	1.4.2048 - 31.3.2049	= 18.0			
	1.4.2049 - 31.3.2050	= 4.9			
	1.4.2050 - 31.3.2051	= 22.9			
	1.4.2051 - 31.3.2052	= 18.0			
	1.4.2052 - 31.3.2053	= 9.8			
	1.4.2053 - 31.3.2054	= 22.9			
	1.4.2054 - 31.3.2055	= 4.9			
	1.4.2055 - 31.3.2056	= 18.0			
	1.4.2056 - 31.3.2057	= 9.8			
	1.4.2057 - 31.3.2058	= 18.0			
	1.4.2058 - 31.3.2059	= 18.0			
	1.4.2059 - 31.3.2060	= 0			
	1.4.2060 - 31.3.2061	= 18.0			
	1.4.2061 - 31.3.2062	= 18.0			
	1.4.2062 - 31.3.2063	= 18.0			
	1.4.2063 - 31.3.2064	= 26.5			
	1.4.2064 - 31.3.2065	= 0			
	1.4.2065 - 31.3.2066	= 26.5			
	1.4.2066 - 31.3.2067	= 4.9			
	1.4.2067 - 31.3.2068	= 21.5			
	1.4.2068 - 31.3.2069	= 31.4			
	1.4.2069 - 31.3.2070	= 0			
	1.4.2070 - 31.3.2071	= 4.9			
	1.4.2071 - 31.3.2072	= 26.5			
	1.4.2072 - 31.3.2073	= 0			
	1.4.2073 - 31.3.2074	= 4.9			
	1.4.2074 - 31.3.2075	= 21.5			
	1.4.2075 - 31.3.2076	= 4.9			
	1.4.2076 - 31.3.2077	= 0			
	1.4.2077 - 31.3.2078	4.9			
	1.4.2078 - 31.3.2079	21.5			
	1.4.2079 - 31.3.2080	4.9			
	1.4.2080 - 31.3.2081	26.5			
	1.4.2081 - 31.3.2082	0			
	1.4.2082 - 31.3.2083	26.5			
	1.4.2083 - 31.3.2084	4.9			
	1.4.2084 - 31.3.2085	23.3			
	1.4.2085 - 31.3.2086	0			
	1.4.2086 - 31.3.2087	4.9			
	1.4.2087 - 31.3.2088	0			
	1.4.2088 - 31.3.2089	44.9			
	1.4.2089 - 31.3.2090	4.9			
	1.4.2090 - 31.3.2091	40.0			
	1.4.2091 - 31.3.2092	0			

1.4.2092 - 31.3.2093	44.9
1.4.2093 - 31.3.2094	0
1.4.2094 - 31.3.2095	40.0
1.4.2095 - 31.3.2096	4.9
1.4.2096 - 31.3.2097	0
1.4.2097 - 31.3.2098	0
1.4.2098 - 31.3.2099	0
1.4.2099 - 31.3.2100	4.9
1.4.2100 - 31.3.2101	0
1.4.2101 - 31.3.2102	4.9
1.4.2102 - 31.3.2103	0
1.4.2103 - 31.3.2104	4.9
1.4.2104 - 31.3.2105	0
1.4.2105 - 31.3.2106	4.9
1.4.2106 - 31.3.2107	0
1.4.2107 - 31.3.2108	0
1.4.2108 - 31.3.2109	0
1.4.2109 - 31.3.2110	4.9
1.4.2110 - 31.3.2111	0
1.4.2111 - 31.3.2112	4.9
1.4.2112 - 31.3.2113	0
1.4.2113 - 31.3.2114	4.9
1.4.2114 - 31.3.2115	0
1.4.2115 - 31.3.2116	4.9

Total future arisings: **971.5**
Total waste volume: **991.2**

Number of waste packages in stock: At 1.4.2025…… - packages

Comment on arising rates: Production period is based on the 27 boats currently within scope of SDP, plus seven existing/planned Astute boats and four future Dreadnought class boats.
Existing stock comprises LLW from the first two initial-dismantled submarines, including steam generators from one of those submarines Subsequently, primary circuit LLW will be disposed of at approximately two-year intervals, lagging completion of the ABC23 dismantling programme by one year.
It is assumed that a GDF is operational from 2040 and that RPVs are removed from the interim ILW store from 2070, size-reduced, and ILW consigned to the GDF and LLW to a LLW disposal site at six-month intervals. Dreadnought RPVs would be consigned direct to the GDF.

Additional information on quantities: LLW/ILW partitioning in RPV body and internal components has not been determined empirically and is subject to +/- 50% modelling error.

Uncertainty factors on volumes:

Stock (upper):	x 0.00	Arisings (upper):	x 1.20
Stock (lower):	x 1.00	Arisings (lower):	x 0.80

WASTE SOURCE Dismantling of nuclear steam-raising plant.

PHYSICAL CHARACTERISTICS

General description: The waste is composed of PWR primary circuit components that are contaminated with activated crud, together with activated structural steel from the primary shield tank. Baseline assumption is that at the end of decay storage the RPV will be size-reduced and LLW disposed to the LLWR.

Changes since waste generated: Size reduction of vessels, pipework, and components, will be performed to achieve configuration that is compatible with standard disposal containers.

Bulk density (t/m³): ~ 7.9

Comment on density: Quoted density is that of stainless steel.

CHEMICAL COMPOSITION

General description and components (%wt): Stainless steel and ferrous metal (100%wt).

Chemical state: Neutral

Sheet metal proportion / thickness: Steel plate 6% - thickness approximately 50mm; steel plate 4% - thickness 25mm; stainless steel 85% -pipework outside diameters approximately 13mm to 360mm. Low alloy steel (5%) pipework outside diameters 13mm to 360mm.

Metals and alloys (%wt):

	(%wt)	Type(s) / Grades(s) with proportions	% of total C14 activity
Stainless steel	~ 90.0	Stainless steel: C <0.08%; Si >0.2<0.8%; Cr >16.25 <17.5%; Ni >11<13%; Mn<2%; Co <0.05%; Ta <0.03%; P <0.035%; S <0.03%; N <0.08%; Mo >2<2.7%; Fe balance.	100.0
Other ferrous metals	~ 10.0	Structural (low alloy) steel: C <0.15%; Si <0.3%; Mn <1.2%; Ni <1.2%; Mo <0.5%; V <0.12%; S <0.04%; P <0.03%.	
Iron		-	
Aluminium	= 0	-	
Beryllium	= 0	-	
Cobalt	TR 0	-	
Copper	TR	-	
Lead	= 0	-	
Magnox/Magnesium	= 0	-	
Nickel	= 0	-	
Titanium	0	-	
Uranium	= 0	-	
Zinc	= 0	-	
Zircaloy/Zirconium	TR	-	
Other metals	= 0	-	

Organics (%wt):

	(%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	TR	-	
Oil or grease	TR	-	
Fuel	= 0	-	
Asphalt/Tarmac (cont.coal tar)	= 0	-	
Asphalt/Tarmac (no coal tar)	= 0	-	
Bitumen	= 0	-	
Others	= 0	-	
Other organics	= 0	-	

Other materials (%wt):

	(%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	= 0	-	
Glass/Ceramics	= 0	-	
Graphite	= 0	-	
Desiccants/Catalysts		-	
Asbestos	TR	-	
Non/low friable	TR	Small quantities contained in valve gaskets	
Moderately friable		-	
Highly friable		-	
Free aqueous liquids	= 0	-	
Free non-aqueous liquids	= 0	-	
Powder/Ash	= 0	-	

COMPONENTS OF MATERIALS, WASTE PROPERTIES, MATERIALS NOT CONTRIBUTING TO MASS

Inorganic anions (%wt):

	(%wt)	Type(s) and comment
Fluoride	= 0	-
Chloride	= 0	-
Iodide	= 0	-
Cyanide	= 0	-
Carbonate	= 0	-
Nitrate	= 0	-
Nitrite	= 0	-
Phosphate	= 0	-
Sulphate	= 0	-
Sulphide	= 0	-

Materials of interest for waste acceptance criteria:

	(%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	= 0	-
Corrosive materials	= 0	-
Pyrophoric materials	= 0	-
Generating toxic gases	= 0	-
Reacting with water	= 0	-
Higher activity particles	= 0	-
Soluble solids as bulk chemical compounds	= 0	-

Hazardous substances / non hazardous pollutants: -

	(%wt)	Type(s) and comment
Acrylamide		-
Benzene	= 0	-
Chlorinated solvents		-
Formaldehyde		-
Organometallics		-
Phenol	= 0	-
Styrene		-
Tri-butyl phosphate	= 0	-
Other organophosphates		-
Vinyl chloride	= 0	-
Arsenic	= 0	-
Barium		-
Boron	= 0	-
Boron (in Boral)		-
Boron (non-Boral)		-
Cadmium	= 0	-
Caesium		-
Selenium	= 0	-
Chromium	TR 0	Possible trace K2CrO4 (Cr(vi) deposits on some components
Molybdenum	= 0	-
Thallium		-
Tin	= 0	-
Vanadium	= 0	-
Mercury compounds		-
Others	= 0	-

Complexing agents (%wt): No

	(%wt)	Type(s) and comment
EDTA		-
DPTA		-
NTA		-
Polycarboxylic acids	0	-
Other organic complexants		-
Total complexing agents	= 0	-

Physical components:

	Number	Type(s) and comment
Sources		-
Electronic & Electrical Equipment (EEE)		-
EEE Type 1		-
EEE Type 2		-
EEE Type 3		-
EEE Type 4		-
EEE Type 5		-

TREATMENT, PACKAGING AND DISPOSAL

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

Treatment	On-site / Off-site	Stream volume %
Size reduction		
Decay storage	Off-site	= 20.0
Low force compaction		
Supercompaction (HFC)		
Incineration		
Drying/dewatering/liquid separation		
Tie down/fixatives/strippable coating/painting application		
Decontamination		
Metal treatment		
Recycling / reuse		
Thermal treatment, including vitrification		
Encapsulation		
Polymer encapsulation		
Other physical treatment		
Other chemical treatment		
Containerisation		
Treatment not yet determined		
None		= 80.0

Comments on planned treatments: Reactor pressure vessels will be decay-stored at the Capenhurst interim ILW store pending opening of a GDF, at which point they will be size-reduced and segregated into ILW and LLW. It is assumed LLW sections will then be loaded into THISO containers and consigned to LLWR for disposal.

Conditioning method: -

Conditioning plants:

Plant Name	Location

Likely conditioning matrix: -

Further information on the conditioning matrix: -

Waste Packaging:

Likely container type:

Container	Waste packaged (vol%)	Waste loading (m^3)	Payload (m^3)	Number of packages	Estimated start date for packaging
1/3 Height IP-2 ISO (TC03)	30.0	2.3	11.5	130	-
1 t flexible intermediate bulk container (FIBC)	40.0	0.13	0.13	3050	-
210 l steel drum (TC14)	23.0	0.03	0.03	7600	-
Non-containerised	7.0	-	-	-	-

Range in container waste loading:

Other information on packaging and conditioning: -

Conditioned density (t/m^3): -
Conditioned density comment: -

Management Routes:

Disposal Route	Stream volume %	Raw density t/m^3	Start date
Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland)			
Expected to be Non-NSD HAW managed under Scottish Government's policy			
Expected to be disposed to LLW Vaults NRS Dounreay			
Expected to be consigned to the Geological Disposal Facility			
Expected to be consigned to a Near Surface Disposal Facility			
Expected to be consigned to the LLW Repository	~ 52.0	~ 7.9	2025
Expected to be consigned to a Landfill Facility	~ 48.0	~ 7.9	2025
Expected to be disposed On-Site			
Expected to be managed by In-Situ Disposal			
Expected to be consigned to an Incineration Facility			
Expected to be consigned to a Metal Treatment Facility			
Expected to be Out of Scope			
Expected to be recycled / reused			
Disposal route not known			

Classification codes for waste expected to be consigned to a landfill facility:

Opportunities for alternative disposal routing: Yes

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Opportunity Confidence	Comment
Landfill	Metal treatment facility	~ 47.0	AMBER	Treatment trials underway
LLWR	Near-site NSDF	~ 20.0	AMBER	Potential for RPV emplacement, including LLW component, at NSD

RADIOACTIVITY

Source:

Contamination of PWR primary circuit components with activated crud. Neutron activation of reactor pressure vessel and primary shield tank.
The radionuclide fingerprint has been modifed by the removal of actinides and fission products that were pessimistically included in the previous submission but have subsequently been confirmed absent, in line with assumptions on nuclear fuel integrity.

Uncertainty:

Activation of RPV and shield tank steel using ATTILA and CAIRN codes. Error in flux model assessed to be +/- 30%. Uncertainty in nuclear data, material composition and operating history increases the overall error to +/-50%.
Activity of surface contaminated objects derived by application of a radionuclide fingerprint developed from a primary circuit sampling and analysis campaign. Error in ISOCS measurements arising from uncertainty in geometry/packing factors estimated to be +/- 25%

Measurement of radioactivities:

Activity of surface contaminated objects derived by application of a radionuclide fingerprint developed from a primary circuit sampling and analyis campaign. Fingerprint applied to ISOCS measurement of cobalt-60 concentrations in packaged waste. Fingerprint decay-corrected to 40 years from reactor shutdown (predicted average for SDP boats) and mean weighting factor applied.
Activated components' radioactivity content estimated by numerical modelling that is subject to an ongoing programme of validation by characterisation.

Chemical form of radionuclides:

H-3: -
C-14: Present in magnetite crud layer and activated steel
Cl-36: -
Se-79: -
Tc-99: -
I-129: -
Ra: -
Th: -
U: -
Np: -
Pu: -

WASTE STREAM **7G103** **LLW from Decommissioned Submarines**

Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2025	Bands and Code	Future Arisings	Bands and Code
H 3	~ 8.60E-09	A A 2	~ 5.41E-09	A A 2	Gd 153				
Be 10					Ho 163				
C 14	~ 3.72E-04	A A 2	~ 2.46E-04	A A 2	Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36					Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54					Pb 205				
Fe 55	~ 5.11E-06	A A 2	~ 6.23E-06	A A 2	Pb 210				
Co 60	~ 4.51E-04	A A 2	~ 2.84E-04	A A 2	Bi 208				
Ni 59	~ 2.26E-05	A A 2	~ 2.07E-05	A A 2	Bi 210m				
Ni 63	~ 2.60E-03	A A 2	~ 1.58E-03	A A 2	Po 210				
Zn 65					Ra 223				
Se 79					Ra 225				
Kr 81					Ra 226				
Kr 85					Ra 228				
Rb 87					Ac 227				
Sr 90	~ 2.22E-07	A A 2	~ 1.63E-07	A A 2	Th 227				
Zr 93					Th 228				
Nb 91					Th 229				
Nb 92					Th 230				
Nb 93m					Th 232				
Nb 94					Th 234				
Mo 93					Pa 231				
Tc 97					Pa 233				
Tc 99					U 232				
Ru 106					U 233				
Pd 107					U 234				
Ag 108m					U 235				
Ag 110m					U 236				
Cd 109					U 238				
Cd 113m					Np 237				
Sn 119m					Pu 236				
Sn 121m					Pu 238				
Sn 123					Pu 239				
Sn 126					Pu 240				
Sb 125					Pu 241				
Sb 126					Pu 242				
Te 125m					Am 241				
Te 127m					Am 242m				
I 129					Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	~ 8.40E-08	A A 2	~ 5.28E-08	A A 2	Cm 244				
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145					Cf 250				
Pm 147					Cf 251				
Sm 147					Cf 252				
Sm 151					Unsp a				
Eu 152					Unsp b/g				
Eu 154					**Total a**	**0**	*	**0**	*
Eu 155					**Total b/g**	**3.45E-03**	*	**2.14E-03**	*

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 the 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
* Total calculated from the 114 declared radionuclides