

<b>WASTE STREAM</b>	<b>9B21</b>	<b>FED Magnox, Gravel and Interface</b>
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**SITE** Bradwell  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Magnox Limited  
**WASTE TYPE** LLW

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2016.....	328.0 m <sup>3</sup>
Total future arisings:		0 m <sup>3</sup>
Total waste volume:		328.0 m <sup>3</sup>

**Comment on volumes:** The current stock at Bradwell is based on the retrieval records less dissolved FED. This recorded a total of 1345-off 200-litre drums of sorted FED/gravel retrieved. The volume has been re-estimated from previous submissions following retrieval from the vaults into drums.

<b>Uncertainty factors on volumes:</b>	Stock (upper):	x 1.2	Arisings (upper)	x
	Stock (lower):	x 0.8	Arisings (lower)	x

**WASTE SOURCE**

The source of the waste is the removal of splitters from fuel elements prior to dispatch of the elements for reprocessing. Contaminated gravel (stone chippings) on the floor of the waste cell containing Magnox fuel element debris. The gravel was applied before any waste was discharged to the facilities. This waste stream is an amalgamation of 9B19, 9B21, 9B22, 9B23, 9B24, 9B25 (part), 9B26, 9B34, 9B35, 9B40, 9B41, 9B42, 9B60, 9B61 & 9B62.

**PHYSICAL CHARACTERISTICS**

**General description:** The waste consists of Magnox metal which may be contaminated by fission products and actinides and gravel (stone chippings) which was applied to the floor of the waste cell containing Magnox fuel element debris before any waste was discharged to the facilities. The waste stream data for the gravel aspect of the stream is based on contamination absorbed into the material structure. The waste in the drums has been sorted and activated components such as nimonic springs, thermocouple wires, top end fittings and fuel fragments have been removed. The FED material has been segregated from loose corrosion products and dust/sludge debris and is predominantly dry. The FED, gravel and the interface material (which comprises a mixture of both) have been drummed separately but will be disposed of together.

**Physical components (%wt):** Individual components of FED Magnox (60%) may weigh up to about 100 g and be approx. 2 mm x 25 mm x 900 mm. Complete splitter frames weighing about 600 g may have been compressed into a cylinder about 225 mm long by 100 mm diameter. There are no large items in the waste which will require special handling. The FED material was placed directly into un-shielded 200-litre drums for storage in Building 101 and Circulator Hall 2 (which have both been modified for this purpose). Contaminated gravel (39%) is likely to be either limestone or silica based. A notional 1% has been included to account for the secondary PPE and filter waste from supercompaction.

**Sealed sources:** The waste does not contain sealed sources.

**Bulk density (t/m<sup>3</sup>):** 0.42

**Comment on density:** The maximum density is 1.7 te/m<sup>3</sup>, being the density of the Magnox material. The original average density of 0.28 for Magnox material only, assumes a packing factor of approximately 6 times the displacement volume of the material. The actual bulk density is potentially due to the presence of heavier corrosion products; typically Magnesium Hydroxide [Mg(OH)<sub>2</sub>] and more complex products such as Hydromagnesite [Mg<sub>5</sub>(CO<sub>3</sub>)<sub>4</sub>(OH)<sub>2</sub>.4H<sub>2</sub>O] and Huntite [Mg<sub>3</sub>Ca(CO<sub>3</sub>)<sub>4</sub>]. The bulk density is based on the stock of 1345-off drums with net contents of 139te. The gravel is assumed to be either limestone or silica based.

**CHEMICAL COMPOSITION**

**General description and components (%wt):** Magnox metal (type ZR55) (>60%), fission product and actinide contamination. The potential corrosion products present are detailed in the section above. The quantities/ratios of each potential corrosion product is currently unknown. The chemical composition of the chippings is not known. It is likely that either silica or limestone has been used. Fission products, actinides and other activation products will be present as contaminants.

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Chemical state: Neutral

Chemical form of radionuclides: H-3: Tritium is expected to be present as surface contamination possibly as water but perhaps in the form of other inorganic compounds or as organic compounds.  
 C-14: Carbon 14 will probably be present as graphite.  
 Cl-36: Chlorine 36 incorporated in the Magnox may be associated with barium impurity (BaCl<sub>2</sub>). Other chlorine 36 may be associated with surface contamination.  
 U: Chemical form of U isotopes has not been determined but may be oxides.  
 Np: The chemical form of Neptunium has not been determined.  
 Pu: Chemical form of Pu isotopes has not been determined but may be oxides.

## Metals and alloys (%wt):

The thickness of some of the waste will be of the order of a mm or less.

Stainless steel..... 0

Other ferrous metals..... <0.01

Aluminium..... <0.01

Beryllium..... 0

Cobalt.....

Copper..... TR

Lead..... P

Magnox/Magnesium..... >60.0

Nickel.....

Titanium.....

Uranium..... 0

Zinc..... P

Zircaloy/Zirconium..... TR

Other metals..... 0

The waste is 60% Magnox ZR55 which includes zirconium as an alloying constituent.

## Organics (%wt):

-

Total cellulose..... 1.0

    Paper, cotton..... 1.0

    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

Other organics..... TR

## Other materials (%wt):

-

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Inorganic ion exchange materials.....	0
Inorganic sludges and flocs.....	NE
Soil.....	0
Brick/Stone/Rubble.....	39.0
Cementitious material.....	0
Sand.....	0
Glass/Ceramics.....	0
Graphite.....	TR
Desiccants/Catalysts.....	0
Asbestos.....	0
Chrysotile.....	
Amosite.....	
Crocidolite.....	
Free aqueous liquids.....	TR
Free non-aqueous liquids.....	0
Powder/Ash.....	

Inorganic anions (%wt):

-	
Fluoride.....	0
Chloride.....	TR
Iodide.....	0
Cyanide.....	0
Carbonate.....	TR
Nitrate.....	TR
Nitrite.....	TR
Phosphate.....	TR
Sulphate.....	TR
Sulphide.....	0

Materials of interest for waste acceptance criteria:

Magnox will ignite under appropriate conditions. There may be some Magnox mixed with the gravel. This could ignite under appropriate conditions.

Combustible metals.....	Yes	>60%
Low flash point liquids.....	No	
Explosive materials.....	No	
Phosphorus.....	No	
Hydrides.....	No	
Biological etc. materials.....	No	
Biodegradable materials.....	No	
Putrescible wastes.....	No	
Non-putrescible wastes.....	No	
Corrosive materials.....	No	
Pyrophoric materials.....	No	
Generating toxic gases.....	No	
Reacting with water.....	Yes	>60% Magnox
Active particles.....		

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Soluble solids as bulk chemical compounds.....

Hazardous substances / non hazardous pollutants:

-

Vinyl chloride.....

Tri-butyl phosphate.....

Phenol.....

Benzene.....

Arsenic.....

Boron.....

Cadmium.....

Selenium.....

Chromium.....

Molybdenum.....

Tin.....

Vanadium.....

Others.....

Complexing agents (%wt):

Not yet determined

Aminopolycarboxylic acids.....

Polycarboxylic acids.....

Other organic complexants.....

Total complexing agents.....

**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 Recycling / reuse Other / various None	Off-site	100.0

Comment on planned treatments:

-

**Disposal Routes:**

Disposal Route	Stream volume %
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	100.0

**Upcoming (2016/7-2018/19) Waste Routing:**

Disposal Route	Stream volume %		
	2016/17	2017/18	2018/19
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 m <sup>3</sup>	Number of packages
1/3 Height IP-1 ISO	100.0	~10	33
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)			
Other			

Other information: -

**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 has a current WCH.  
Inventory information is consistent with the current WCH.

Waste consigned for disposal to LLWR in year of generation: -

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: -

**RADIOACTIVITY**

Source: The source of the waste is the removal of splitters from fuel elements prior to dispatch of the elements for reprocessing. Activation of trace elements in the Magnox and contamination by fission products and actinides will be the main sources of activity.

Uncertainty: The values quoted are indicative of the activities that might be expected.

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: Values were derived from measurements, calculations of induced activity and estimates of likely contamination. A campaign of sampling was undertaken during the retrieval of the material. Values above are based on WCH for LLWR ref 1MXN-3BRA-0-WCH-L-3403 v 2

Other information: The activities quoted do not include any allowance for the activity of Nimonic springs or

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zirconium alloy in top end fittings – these items are now removed from this waste stream and are accounted for in waste stream 9B79.

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Nuclide	Mean radioactivity, TBq/m <sup>3</sup>				Nuclide	Mean radioactivity, TBq/m <sup>3</sup>			
	Waste at 1.4.2016	Bands and Code	Future arisings	Bands and Code		Waste at 1.4.2016	Bands and Code	Future arisings	Bands and Code
H 3	3.8E-03	C C 2			Gd 153		8		
Be 10		8			Ho 163		8		
C 14	5.72E-05	C C 2			Ho 166m		8		
Na 22		8			Tm 170		8		
Al 26		8			Tm 171		8		
Cl 36		8			Lu 174		8		
Ar 39		8			Lu 176		8		
Ar 42		8			Hf 178n		8		
K 40		8			Hf 182		8		
Ca 41		8			Pt 193		8		
Mn 53		8			Tl 204		8		
Mn 54		8			Pb 205		8		
Fe 55	6.87E-09	C C 2			Pb 210		8		
Co 60	1.55E-04	C C 2			Bi 208		8		
Ni 59		8			Bi 210m		8		
Ni 63	3.96E-08	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	4.03E-09	C C 2			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	1.81E-08	C C 2		
Sn 119m		8			Pu 236		8		
Sn 121m		8			Pu 238	7.92E-06	C C 2		
Sn 123		8			Pu 239	1.5E-05	C C 2		
Sn 126		8			Pu 240	1.5E-05	C C 2		
Sb 125		8			Pu 241	5.84E-09	C C 2		
Sb 126		8			Pu 242		8		
Te 125m		8			Am 241	6.06E-05	C C 2		
Te 127m		8			Am 242m		8		
I 129		8			Am 243		8		
Cs 134		8			Cm 242	1E-08	C C 2		
Cs 135		8			Cm 243	1.09E-07	C C 2		
Cs 137	1.36E-09	C C 2			Cm 244	1.07E-07	C C 2		
Ba 133		8			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		8			Other a		8		
Eu 152		8			Other b/g		8		
Eu 154		8			<b>Total a</b>	<b>9.88E-05</b>	<b>C C 2</b>		<b>0</b>
Eu 155		8			<b>Total b/g</b>	<b>4.01E-03</b>	<b>C C 2</b>		<b>0</b>

**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