

| WASTE STREAM | 5B325 | DFR Ion Exchange Columns |
|--------------|-------|--------------------------|
|--------------|-------|--------------------------|

**SITE** Dounreay

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Nuclear Restoration Services Ltd (NRS)

**WASTE TYPE** ILW

#### WASTE VOLUMES

|                        | Reported (m <sup>3</sup> ) | OR    | Conditioned (m <sup>3</sup> ) | Packaged (m <sup>3</sup> ) |
|------------------------|----------------------------|-------|-------------------------------|----------------------------|
| Stocks:                | At 1.4.2025                | = 1.6 |                               |                            |
| Future arisings:       | 1.4.2028 - 31.3.2029       | = 0.4 |                               |                            |
| Total future arisings: |                            | 0.4   |                               |                            |
| Total waste volume:    |                            | 2.0   |                               |                            |

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

Comment on arising rates: Programme data is based on Life Time Plan 2024 dataset generated in December 2023

Additional information on quantities: -

Uncertainty factors on volumes: Stock (upper): x 1.02 Arisings (upper): x 1.10  
Stock (lower): x 0.98 Arisings (lower): x 0.90

**WASTE SOURCE** The ion-exchange columns were used in a treatment plant to remove radioactivity, mainly Cs-137, from DFR sodium/potassium alloy, which was used as a reactor coolant and primary heat exchanger.

#### PHYSICAL CHARACTERISTICS

General description: Cs treatment ion exchange columns will be fabricated from 40 mm thick polypropylene to prevent any adverse interaction between the chloride ions in the process liquor and steel components. The column will be completely enclosed in a 3 mm 304L stainless steel container that will provide protection during handling and provide the long-term containment once chloride ions have been flushed from the columns after use.

Changes since waste generated: -

Bulk density (t/m<sup>3</sup>): = 0.80

Comment on density: Based on actuals data from Dounreay's waste consignment system. Data considered acceptable for 2025 submission.

#### CHEMICAL COMPOSITION

General description and components (%wt): Inorganic ion exchange materials (53.00%), Lead (7.00%), Stainless steel (40.00%),

Chemical state: Neutral

Sheet metal proportion / thickness: This waste is unsuitable for further treatment. Therefore, the proportion of sheet metal not been assessed.

Metals and alloys (%wt):

|                           | (%wt)  | Type(s) / Grades(s) with proportions | % of total C14 activity |
|---------------------------|--------|--------------------------------------|-------------------------|
| Stainless steel.....      | = 40.0 | 304L                                 |                         |
| Other ferrous metals..... | = 0    | -                                    |                         |
| Iron.....                 | = 0    | -                                    |                         |
| Aluminium.....            | = 0    | -                                    |                         |
| Beryllium.....            | = 0    | -                                    |                         |
| Cobalt.....               | = 0    | -                                    |                         |
| Copper.....               | = 0    | -                                    |                         |
| Lead.....                 | = 7.0  | -                                    |                         |
| Magnox/Magnesium.....     | = 0    | -                                    |                         |
| Nickel.....               | = 0    | -                                    |                         |
| Titanium.....             | = 0    | -                                    |                         |
| Uranium.....              | = 0    | -                                    |                         |
| Zinc.....                 | = 0    | -                                    |                         |
| Zircaloy/Zirconium.....   | = 0    | -                                    |                         |
| Other metals.....         | = 0    | -                                    |                         |

Organics (%wt):

|                                     | (%wt) | Type(s) and comment | % of total C14 activity |
|-------------------------------------|-------|---------------------|-------------------------|
| Total cellulotics.....              | = 0   | -                   |                         |
| Paper, cotton.....                  | = 0   | -                   |                         |
| Wood.....                           | = 0   | -                   |                         |
| Halogenated plastics.....           | = 0   | -                   |                         |
| Total non-halogenated plastics..... | = 0   | -                   |                         |
| Condensation polymers.....          | NE    | -                   |                         |
| Others.....                         | NE    | -                   |                         |
| Organic ion exchange materials..... | = 0   | -                   |                         |
| Total rubber.....                   | = 0   | -                   |                         |
| Halogenated rubber.....             | NE    | -                   |                         |
| Non-halogenated rubber.....         | NE    | -                   |                         |
| Hydrocarbons.....                   | = 0   | -                   |                         |
| Oil or grease.....                  | = 0   | -                   |                         |
| Fuel.....                           | NE    | -                   |                         |
| Asphalt/Tarmac (cont.coal tar)..... | = 0   | -                   |                         |
| Asphalt/Tarmac (no coal tar).....   | = 0   | -                   |                         |
| Bitumen.....                        | = 0   | -                   |                         |
| Others.....                         | NE    | -                   |                         |
| Other organics.....                 | = 0   | -                   |                         |

Other materials (%wt):

|                                       | (%wt)  | Type(s) and comment | % of total C14 activity |
|---------------------------------------|--------|---------------------|-------------------------|
| Inorganic ion exchange materials..... | = 53.0 | -                   |                         |
| Inorganic sludges and flocs.....      | = 0    | -                   |                         |
| Soil.....                             | = 0    | -                   |                         |
| Brick/Stone/Rubble.....               | = 0    | -                   |                         |
| Cementitious material.....            | = 0    | -                   |                         |
| Sand.....                             | = 0    | -                   |                         |
| Glass/Ceramics.....                   | = 0    | -                   |                         |
| Graphite.....                         | = 0    | -                   |                         |
| Desiccants/Catalysts.....             | = 0    | -                   |                         |
| Asbestos.....                         | = 0    | -                   |                         |
| Non/low friable.....                  | NE     | -                   |                         |
| Moderately friable.....               | NE     | -                   |                         |
| Highly friable.....                   | NE     | -                   |                         |
| 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.....  | NE    | -                   |
| Iodide.....    | NE    | -                   |
| Cyanide.....   | = 0   | -                   |
| Carbonate..... | NE    | -                   |
| Nitrate.....   | NE    | -                   |
| Nitrite.....   | NE    | -                   |
| Phosphate..... | = 0   | -                   |
| Sulphate.....  | = 0   | -                   |
| Sulphide.....  | NE    | -                   |

Materials of interest for waste acceptance criteria:

|                                                | (%wt) | Type(s) and comment |
|------------------------------------------------|-------|---------------------|
| Combustible metals.....                        | NE    | -                   |
| Low flash point liquids.....                   | NE    | -                   |
| Explosive materials.....                       | NE    | -                   |
| Phosphorus.....                                | NE    | -                   |
| Hydrides.....                                  | NE    | -                   |
| Biological etc. materials.....                 | NE    | -                   |
| Biodegradable materials.....                   | = 0   | -                   |
| Putrescible wastes.....                        | NE    | -                   |
| Non-putrescible wastes.....                    | NE    | -                   |
| Corrosive materials.....                       | NE    | -                   |
| Pyrophoric materials.....                      | NE    | -                   |
| Generating toxic gases.....                    | NE    | -                   |
| Reacting with water.....                       | = 0   | -                   |
| Higher activity particles.....                 | NE    | -                   |
| Soluble solids as bulk chemical compounds..... | NE    | -                   |

Hazardous substances / non hazardous pollutants:

|                             | (%wt) | Type(s) and comment |
|-----------------------------|-------|---------------------|
| Acrylamide.....             | NE    | -                   |
| Benzene.....                | = 0   | -                   |
| Chlorinated solvents.....   | NE    | -                   |
| Formaldehyde.....           | NE    | -                   |
| Organometallics.....        | NE    | -                   |
| Phenol.....                 | NE    | -                   |
| Styrene.....                | NE    | -                   |
| Tri-butyl phosphate.....    | NE    | -                   |
| Other organophosphates..... | NE    | -                   |
| Vinyl chloride.....         | NE    | -                   |
| Arsenic.....                | = 0   | -                   |
| Barium.....                 | NE    | -                   |
| Boron.....                  | = 0   | -                   |
| Boron (in Boral).....       | NE    | -                   |
| Boron (non-Boral).....      | NE    | -                   |
| Cadmium.....                | = 0   | -                   |
| Caesium.....                | NE    | -                   |
| Selenium.....               | = 0   | -                   |
| Chromium.....               | = 0   | -                   |
| Molybdenum.....             | = 0   | -                   |
| Thallium.....               | NE    | -                   |
| Tin.....                    | = 0   | -                   |
| Vanadium.....               | = 0   | -                   |
| Mercury compounds.....      | = 0   | -                   |
| Others.....                 | NE    | -                   |

Complexing agents (%wt):

| Not yet determined             |       |                     |
|--------------------------------|-------|---------------------|
|                                | (%wt) | Type(s) and comment |
| EDTA.....                      | NE    | -                   |
| DPTA.....                      | NE    | -                   |
| NTA.....                       | NE    | -                   |
| Polycarboxylic acids.....      | NE    | -                   |
| Other organic complexants..... | NE    | -                   |
| Total complexing agents.....   | NE 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<br>Decay storage<br>Low force compaction<br>Supercompaction (HFC)<br>Incineration<br>Drying/dewatering/liquid separation<br>Tie down/fixatives/strippable coating/painting application<br>Decontamination<br>Metal treatment<br>Recycling / reuse<br>Thermal treatment, including vitrification<br>Encapsulation<br>Polymer encapsulation<br>Other physical treatment<br>Other chemical treatment<br>Containerisation<br>Treatment not yet determined<br>None | On-site            | = 100.0         |

Comments on planned treatments:

The preferred option is to cement the IX columns into 500 l drums.

Conditioning method:

Waste will be conditioned using grout matrix in to 500l drums. This will be done through a dedicated ILW repackaging facility, which will handle both RHILW and CHILW 200l drums. This facility will produce conditioned 500l drums.

Conditioning plants:

| Plant Name                        | Location |
|-----------------------------------|----------|
| Combined ILW Repackaging Facility | Dounreay |

Likely conditioning matrix:

Non-standard

Further information on the conditioning matrix:

Dounreay uses 1:3 OPC:PFA, 42% water

#### Waste Packaging:

| Likely container type: | Container                     | Waste packaged (vol%) | Waste loading (m³) | Payload (m³) | Number of packages | Estimated start date for packaging |
|------------------------|-------------------------------|-----------------------|--------------------|--------------|--------------------|------------------------------------|
|                        | 500 l drum (basket for waste) | 100.0                 | 0.24               | 0.40         | 9                  | -                                  |

Range in container waste loading:

Other information on packaging and conditioning: -

Conditioned density (t/m³): = 2.5

Conditioned density comment: Density is if waste is grouted directly into 500l drums. Assume density similar to CHILW repack

#### Management Routes:

| Disposal Route                                                                     | Stream volume % | Raw density t/m³ | Start date |
|------------------------------------------------------------------------------------|-----------------|------------------|------------|
| Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland) | = 100.0         |                  |            |
| 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                                     |                 |                  |            |
| Expected to be consigned to a Landfill Facility                                    |                 |                  |            |
| 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                                                                                                                                                                                                         |
|---------------------------|------------------------------|-------------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Non-NSDF HAW              | Dounreay LLWDV               | NE                | RED                    | There is potential for LLW to be diverted out of this waste stream during repackaging of ILW into 500l drums. However, details of this will be confirmed through the design process of the repackaging facility |

#### RADIOACTIVITY

Source: The activity arises from the decontamination of DFR NaK coolant by ion-exchange. The activity is predominantly caesium.

Uncertainty: Specific Activity data were taken from LoC (both stocks and arisings). Data are best estimates.

Measurement of radioactivities: Ion exchange columns will be a maximum of 200 TBq Cs137.

Chemical form of radionuclides:

- H-3: -
- C-14: -
- Cl-36: -
- Se-79: -
- Tc-99: -
- I-129: -
- Ra: -
- Th: -
- U: -
- Np: -
- Pu: -

| WASTE STREAM |                            | 5B325             |                 | DFR Ion Exchange Columns |           |                            |                   |                 |                   |
|--------------|----------------------------|-------------------|-----------------|--------------------------|-----------|----------------------------|-------------------|-----------------|-------------------|
| Nuclide      | Mean radioactivity, TBq/m³ |                   |                 |                          | Nuclide   | Mean radioactivity, TBq/m³ |                   |                 |                   |
|              | Waste at<br>1.4.2025       | Bands and<br>Code | Future Arisings | Bands and<br>Code        |           | Waste at<br>1.4.2025       | Bands and<br>Code | Future Arisings | Bands and<br>Code |
| H 3          |                            |                   |                 |                          | Gd 153    |                            |                   |                 |                   |
| Be 10        |                            |                   |                 |                          | Ho 163    |                            |                   |                 |                   |
| C 14         |                            |                   |                 |                          | Ho 166m   |                            |                   |                 |                   |
| Na 22        | = 1.12E-03                 | C C 2             | = 1.12E-03      | C C 2                    | Tm 170    |                            |                   |                 |                   |
| Al 26        |                            |                   |                 |                          | Tm 171    |                            |                   |                 |                   |
| Cl 36        |                            |                   |                 |                          | Lu 174    |                            |                   |                 |                   |
| Ar 39        |                            |                   |                 |                          | Lu 176    |                            |                   |                 |                   |
| Ar 42        |                            |                   |                 |                          | Hf 178n   |                            |                   |                 |                   |
| K 40         | = 1.49E-02                 | C C 2             | = 1.49E-02      | C C 2                    | Hf 182    |                            |                   |                 |                   |
| Ca 41        |                            |                   |                 |                          | Pt 193    |                            |                   |                 |                   |
| Mn 53        |                            |                   |                 |                          | Tl 204    |                            |                   |                 |                   |
| Mn 54        |                            |                   |                 |                          | Pb 205    |                            |                   |                 |                   |
| Fe 55        |                            |                   |                 |                          | Pb 210    | = 1.22E-22                 | C C 2             | = 1.22E-22      | C C 2             |
| Co 60        |                            |                   |                 |                          | Bi 208    |                            |                   |                 |                   |
| Ni 59        |                            |                   |                 |                          | Bi 210m   |                            |                   |                 |                   |
| Ni 63        |                            |                   |                 |                          | Po 210    |                            |                   |                 |                   |
| Zn 65        |                            |                   |                 |                          | Ra 223    | = 7.75E-24                 | C C 2             | = 7.75E-24      | C C 2             |
| Se 79        |                            |                   |                 |                          | Ra 225    |                            |                   |                 |                   |
| Kr 81        |                            |                   |                 |                          | Ra 226    | = 4.59E-23                 | C C 2             | = 4.59E-23      | C C 2             |
| Kr 85        |                            |                   |                 |                          | Ra 228    |                            |                   |                 |                   |
| Rb 87        |                            |                   |                 |                          | Ac 227    |                            |                   |                 |                   |
| Sr 90        | = 7.70E-03                 | C C 2             | = 7.70E-03      | C C 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     | = 8.00E-08                 | C C 2             | = 8.00E-08      | C C 2             |
| Ag 110m      |                            |                   |                 |                          | U 236     |                            |                   |                 |                   |
| Cd 109       |                            |                   |                 |                          | U 238     | = 1.45E-07                 | C C 2             | = 1.45E-07      | C C 2             |
| Cd 113m      |                            |                   |                 |                          | Np 237    |                            |                   |                 |                   |
| Sn 119m      |                            |                   |                 |                          | Pu 236    |                            |                   |                 |                   |
| Sn 121m      |                            |                   |                 |                          | Pu 238    | = 3.45E-05                 | C C 2             | = 3.45E-05      | C C 2             |
| Sn 123       |                            |                   |                 |                          | Pu 239    | = 1.32E-03                 | C C 2             | = 1.32E-03      | C C 2             |
| 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       | = 3.52E-03                 | C C 2             | = 3.52E-03      | C C 2                    | Cm 242    |                            |                   |                 |                   |
| Cs 135       | = 3.20E-03                 | C C 2             | = 3.20E-03      | C C 2                    | Cm 243    |                            |                   |                 |                   |
| Cs 137       | = 2.23E+02                 | C C 2             | = 2.23E+02      | C C 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   | 1.35E-03                   | *                 | 1.35E-03        | *                 |
| Eu 155       |                            |                   |                 |                          | Total b/g | 2.23E+02                   | *                 | 2.23E+02        | *                 |

#### 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