



**Dounreay Site  
Restoration Ltd**

Dounreay, Thurso, Caithness  
KW14 7TZ, Scotland  
Tel: +44 (0) 1847 802121  
Fax: +44 (0) 1847 802697  
www.dounreay.com

Miss L Buchan  
SEPA  
5 Redwood Crescent  
Peel Park  
EAST KILBRIDE  
G74 5PP

Direct Line: 01847 806360  
Direct Fax: 01847 806850

Our Reference: D/SEPA/4933N

31 January 2012

**By email and post**

RECEIVED SEPA  
-2 FEB 2012  
EAST KILBRIDE

Dear Linda

**REVIEW OF DISCHARGE ESTIMATES AND LIMITS IN RSA AUTHORISATION APPLICATION**

As you are aware, DSRL recently completed a review of the discharge estimates and proposed limits it originally included in its application for a new RSA Authorisation (submitted in April 2010). The review was undertaken to establish whether those estimates and limits still reflected future decommissioning requirements. Coupled with recent discussions between yourself and Dr Niall Watson to clarify some aspects of the original estimates and limits, some of those estimates have been revised. **None of the revisions to the original estimates requires any increase in the overall site limits originally requested.** Accompanying this letter is an updated issue (1.3) of the RSA Application (09) Estimates document containing these revisions.

The key points to note are listed below.

- The original estimates for the West Minor Sources stack grouping did not include those from the stack for the planned new laboratory (see previous correspondence of 30 September 2011 – ref. D/SEPA/4900R) or the D1211 stack. Whilst that letter states that operations currently undertaken in the D1200, D1226 and Alkali Metal Laboratories will transfer to the new laboratory, it requests that limits are also retained for these three laboratories to enable their decommissioning.
- A limit of  $4.36E+13$  Bq for Krypton-85 has been included for the Fuel Cycle Area (FCA) main stack<sup>1</sup> to reflect a more mature understanding of the fuels held in the D2001 facility. This has been accommodated by reducing the PFR stack group limit from  $5.69E+14$  Bq to  $5.25E+14$  Bq, meaning no change to the overall site limit for Krypton-85 is required.
- To reflect these additions the Site Gaseous T1 table in section 6.3 of the RSA Application (09) Estimates document has been amended. The corresponding table in the RSA

<sup>1</sup> Note that subsequent to the application being submitted in April 2010 the FCA main stack was replaced by new north and south stacks, which became operational in October 2010.

Application (09) Dose document (Table 3 in section 2.3) should also be amended so that it reads as below.

**Table 3: Proposed radionuclide discharge limits (Bq/yr)**

PROPOSED ATMOSPHERIC DISCHARGE LIMITS						
Extant Groupings (as defined in RSA/N/V02/50010/99 Schedule 4)						
Radionuclide	Table 4.4	Table 4.2 & 4.7	Table 4.3	Table 4.6	Table 4.5	Proposed Need Bq/yr
alpha	6.48E+06	1.28E+05	3.00E+05	3.70E+05	2.61E+05	7.28E+06
beta	1.46E+09	7.80E+08	7.00E+08	1.70E+06	1.39E+06	2.94E+09
H-3	5.13E+11	7.50E+13	2.70E+12	2.00E+10	1.16E+10	7.82E+13
Kr-85	4.36E+13	5.25E+14	3.00E+12	4.00E+12	0.00E+00	5.76E+14
I-129	1.00E+09	N/A	N/A	N/A	N/A	1.00E+09

NB the increased alpha limit of 2.61E+05 Bq for the West Minor Sources stack grouping (Table 4.5) results in the individual stack grouping alpha limits totalling slightly more than the originally stated proposed site need of 7.28E+06 Bq. However, there is no need to increase the site proposed need, as there is sufficient headroom in the other stack group limits, principally the FCA main stack (Table 4.4).

- No estimate had originally been included for liquid tritium discharges from 'Rest of Site' areas. An estimate has now been provided, which can be comfortably accommodated within the site liquid tritium limit originally proposed.
- The correct figure for PFR gaseous tritium discharges is that contained in the Table in section 3.7 of the RSA Application (09) Estimates document, i.e. the proposed PFR group limit is 7.50E+13 Bq, not the figure listed in the application form.
- Whilst the PFR Krypton-85 estimate was listed in the application form for both the PFR Irradiated Fuel Buffer Store and the PFR Irradiated Fuel Cave it relates to only one source. The material is currently held in the IFBS (hence it appearing there) but will be transferred in the future and processed in the IFC which discharges to the main PFR stack (hence it also appearing there). The Krypton-85 is more likely to be released via the PFR main stack during processing than the IFBS stack during current storage. Therefore, the Krypton-85 estimate should be attributed to the main PFR stack.

If you have any queries on the content of this letter please do not hesitate to contact Dr Niall Watson on 01847 806197, who will be pleased to assist.

Yours sincerely

  
 A J Scullion *(Peter Thompson)*  
 Director of Assurance

Enc



DSRL	NOT PROTECTIVELY MARKED	DOCUMENT REF: RSA AUTH(09)Estimates
<b>Title:</b> <b>ESTIMATED RELEASES OF RADIOACTIVITY TO THE ENVIRONMENT: JUSTIFICATION AND THE UNCERTAINTY RELATED TO THE ESTIMATES, 2009 (UPDATE JANUARY 2012)</b>		<b>Issue:</b> 1.3 <b>Date:</b> January 2012 <b>Page</b> 2 of 32
<b>Purpose:</b> Application		<b>File No:</b>

	Print Name	Signature	Date
Author	Niall Watson (issue 1.3) Environment Compliance Manager	<i>Niall J. Watson</i>	30.1.2012
Checked	Doug Graham Environment Team Leader	<i>Doug Graham</i>	30.1.2012
Approved <i>pp</i>	Alan Scullion Director of Assurance	<i>Alan Scullion</i>	31/01/12

This document updates the estimated releases of radioactivity to the environment that were included in issue 1.2 which formed part of DSRL's application for a new RSA Authorisation (originally submitted in April 2010). The original estimates and limits have been reviewed to establish whether they still reflect future decommissioning requirements. A short paragraph at the end of each section summaries the changes to the original estimates.

## Revision Record

Issue		Amendment	Date
Draft	First submission draft for consideration		July 2009
1	First submission to Dounreay Environment Committee	Multiple changes after external and internal peer review	August 2009
1.1		Comments from DEC and numerical data check incorporated	September 2009
1.2		Updated to changes since September 2009	March 2010
1.3		Review undertaken of original estimates and limits	January 2012



**Estimated Releases of Radioactivity to the Environment:  
Justification and the Uncertainty Related to the Estimates**

**Update January 2012**

## CONTENTS

1	Introduction	4
2	Dounreay Fast Reactor	5
3	Prototype Fast Reactor	10
4	Gaseous Discharge from Facilities Other than DFR and PFR	17
4.1 – 4.3	D1213 Stack	17
4.4 – 4.5	East Minor Sources	21
4.6 – 4.7	West Minor Sources	24
5	Liquid Discharges from Facilities Other than DFR and DFR	26
6	Conclusions	30

## TABLES

DFR T1	Estimates of Gaseous Discharges from the Dounreay Fast Reactor Project	8
DFR T2	Estimates of Liquid Discharges from the Dounreay Fast Reactor Project	9
PFR T1	Estimates of Gaseous Discharges from the Prototype Fast Reactor Project	13
PFR T2	Estimates of Liquid Discharges from the Prototype Fast Reactor Project	14
D1213 T1	Estimates of Gaseous Discharges from the Fuel Cycle Area Main Stack	19
D1213 T2	Estimates of Gaseous Discharge from Contributory Plants	20
EMS T1	Estimates of Gaseous Discharge from the East Minor Sources	23
WMS T1	Estimates of Gaseous Discharges from the West Minor Sources	25
LIQUID T1	Estimates of Liquid Transfers to the LLETP	28
Site Gaseous T1	Estimates of site gaseous discharges	30
Site Liquid T1	Estimate of site liquid discharges	31

## 1 Introduction

The Dounreay site is undergoing a programme of decommissioning, which by 2025 will see the demolition of all radioactive structures and the build of new facilities to store the higher activity wastes and conditioned fuels. The application for the disposal of radioactive wastes, supported by this document is written to cover the scope of the decommissioning programme, the Dounreay Lifetime Plan (LTP), and the information within are the estimates of radioactive waste discharges to air and water up to the 2025 date.

- 1.1 The application, to which this paper relates, assumes all operations are carried out concurrently in line with the programme of work to decommission the site. Unlike previous applications the scope of the work now includes using techniques and tools for the dismantling of plant and buildings.
- 1.2 The sections 2 to 5 set out the estimated discharges to air and water of radioactive wastes arising from the decommissioning of the Dounreay facilities and infrastructure. This information supporting the estimates of radioactive gaseous and liquid discharges up to 2025 and informing the level of proposed limits, based on the highest estimates in the years 2010 to 2025.
- 1.3 For each of the parts of the site an estimate of the future discharge to air and water has been made. These estimates are further broken down to either the facility or decommissioning project taking account of;
  - historical discharges and the future programme where no new process is proposed; or
  - estimates from the radioactivity inventory and the proposed treatments, taking account of facility BPM studies.
- 1.4 Section 6 sets out the basis for the proposed limits over any 12 month (year) period and summarises those limits. The proposed limits on discharges take account of the process, current or new, adding a contingency allowance that will allow for the uncertainties in the estimates.

## 2 Estimates of Discharges from the Dounreay Fast Reactor (DFR)

- 2.1 In addition to general operations the decommissioning of the DFR, in the time period of the application, will have four major components:
- Care and Maintenance operations and Pond Water disposal
    - NaK disposal operations
    - Breeder Fuel Removal operations
    - Primary Circuit Decontamination
- 2.2 The Care and Maintenance operations and Pond water disposal have previous data to which future disposals can be extrapolated with reasonable accuracy. However, for gaseous discharges, the weekly sample papers are returning results at or just marginally above the minimum detectable activity with consequent uncertainty of the order of 75% to 100%.
- 2.3 The NaK disposal operations are new to DFR, although active commissioning of the NaK Disposal Plant and the associated Ion Exchange Plant has provided information on the gaseous and liquid discharges that can be expected in the operational phase of these plants.
- 2.3.1 Worker dose models derived for the nuclear safety case for the NaK Disposal Plant were used to calculate discharges to atmosphere.
- 2.3.2 Estimates of the radioactive liquid waste activity are calculated using sample results from the primary circuit NaK. The results of the sampling and analysis of the NaK batches during active commissioning has shown that the radiological inventory of the NaK is within the bounding case radiological inventory used to support NDP BPM cases, with the exception of Sr-90.
- 2.3.3 The level of Cs-137 activity in the NaK is relatively consistent (+/- 15%) and aligns very closely with the predicted 1.3 TBq/batch and a total Cs-137 inventory of 460TBq.
- 2.3.4 The total Sr-90 inventory of 126 GBq is approximately an order of magnitude greater than previously estimated (16.5 GBq). The gaseous beta discharges and liquid Sr90 discharges show that Sr-90 is being minimised to close to or below analysis minimum detectable levels.
- 2.3.5 Similarly, the use of a bounding case for Tritium inventory of 2.52TBq of the NaK, based on PFR Sodium Disposal Plant sodium inventory estimates, has been shown to be very pessimistic with an overestimate by two orders of magnitude. The total NaK inventory now assessed as 24 GBq.
- 2.4 The Breeder Fuel Removal operation is a new process for DFR involving the removal of the breeder elements from the DFR reactor vessel, de-cladding the pins and ensuring the clad and fuel pellets are free of any liquid metal coolant.

- 2.4.1 The estimates of release of radionuclides to the liquid stream from the cleaning process include:
- An allowance for residual NaK contamination;
  - Surface strip during the cleaning process (an effect observed during similar operations in France); and
  - FISPIN model calculation of nuclide content of the breeder fuel.
- 2.4.2 The estimates of release to atmosphere are based on assumptions from French experience and application of release fractions within safety assessment models.
- 2.5 The Primary Circuit Decontamination consists of:
- the removal of NaK residues contaminated with
    - oxide and hydride compounds; and
    - fuel residue due to the nature of operation of the DFR reactor.

This particular project will benefit from the experiences gained by carrying out the NDP and BFR projects.

- 2.6 The uncertainties within the estimates are not transparent. The processes to be progressed during DFR decommissioning are new processes. Assumptions used in calculating these estimates may be pessimistic in some cases but may equally be underestimated by virtue of the type of samples taken and analysed. Programme changes may also result in variation to the amount discharged in any one year.
- 2.7 For the gaseous discharge, as the DFR decommissioning project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimated for the NDP project is doubled and the krypton is left as estimated.
- 2.7.1 Review of the original estimates has identified a need to slightly increase the alpha estimate (see table below). However, it does not require alteration of the DFR limit (proposed contribution) originally requested.

Radionuclide	Estimate (Bq/yr)	Revised Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	1.52E+05	1.55E+05	3.00E+05
Beta (Excluding Tritium and Krypton-85)	3.41E+08	3.41E+08	7.00E+08
Tritium	1.36E+12	1.36E+12	2.70E+12
Krypton-85	3.00E+12	3.00E+12	3.00E+12

2.8 For the liquid discharge, as the DFR decommissioning project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimated for the NDP project is doubled and the caesium and strontium are doubled.

2.8.1 Review of the original estimates has identified a need to slightly increase the alpha, beta (excluding tritium) and Strontium estimates (see table below). However, they do not require alteration of the DFR limits (proposed contributions) originally requested.

Radionuclide	Estimate (Bq/yr)	Revised Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	2.00E+08	2.29E+08	4.00E+08
Beta (Excluding Tritium)	6.30E+11	6.38E+11	1.26E+12
Tritium	1.19E+12	1.19E+12	2.40E+12
Strontium-90	7.33E+10	8.14E+10	1.47E+11
Caesium-137	2.81E+11	2.81E+11	5.60E+11

**DFR T1 – ESTIMATES OF GASEOUS DISCHARGES FROM THE DOUNREAY FAST REACTOR PROJECT**

DFR Gaseous Discharges Predicted future 12 month discharges in Bq																		
FACILITY	Nuclide	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
DFR NDP	alpha	4.35E+03	3.90E+03	3.90E+03	3.90E+03	3.90E+03												
	beta	1.15E+05	1.05E+05	1.05E+05	1.05E+05	1.05E+05												
	H-3	1.03E+12	9.18E+11	9.18E+11	9.18E+11	9.18E+11												
DFR POND	alpha	2.00E+03	2.00E+04	1.00E+05	1.00E+05	1.00E+05												
	beta	6.80E+06	6.80E+07	3.40E+08	3.40E+08	3.40E+08												
	H-3	7.08E+09	7.08E+09	7.08E+09	7.08E+09	7.08E+09												
DFR BFR	alpha			2.00E+03	2.00E+03	4.56E+04	4.56E+04	4.56E+04	4.56E+04									
	beta			1.00E+04	1.00E+04	4.08E+05	4.08E+05	4.08E+05	4.08E+05									
	H-3			2.20E+10	2.20E+10	4.32E+11	4.32E+11	4.32E+11	4.32E+11									
DFR RNR	Kr-85			1.50E+11	1.50E+11	3.00E+12	3.00E+12	3.00E+12	3.00E+12									
	alpha									1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03	
	beta									1.73E+04	1.73E+04	1.73E+04	1.73E+04	1.73E+04	1.73E+04	1.73E+04	1.73E+04	
DFR Ops	H-3									1.55E+11	1.55E+11	1.55E+11	1.55E+11	1.55E+11	1.55E+11	1.55E+11	1.55E+11	
	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03
	beta	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04
TOTALS	alpha	1.14E+04	2.89E+04	1.11E+05	1.11E+05	1.55E+05	5.06E+04	5.06E+04	5.06E+04	5.06E+04	6.80E+03	6.80E+03	6.80E+03	6.80E+03	6.80E+03	6.80E+03	6.80E+03	6.80E+03
	beta	6.97E+06	6.82E+07	3.46E+08	3.46E+08	3.41E+08	4.58E+05	4.58E+05	4.58E+05	4.58E+05	6.73E+04	6.73E+04	6.73E+04	6.73E+04	6.73E+04	6.73E+04	6.73E+04	6.73E+04
	H-3	1.04E+12	9.28E+11	9.48E+11	9.48E+11	1.36E+12	4.33E+11	4.33E+11	4.33E+11	4.33E+11	1.56E+11	1.56E+11	1.56E+11	1.56E+11	1.56E+11	1.56E+11	1.56E+11	1.56E+11
	Kr-85	1.80E+08	1.80E+08	1.50E+11	1.50E+11	3.00E+12	3.00E+12	3.00E+12	3.00E+12	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07

**DFR T2 – ESTIMATES OF LIQUID DISCHARGES FROM THE DOUNREAY FAST REACTOR PROJECT**

DFR Liquid Discharges Predicted future 12 month discharge in Bq		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
FACILITY	Nuclide																
DFR NDP	alpha	3.18E+07	2.85E+07	2.85E+07	2.85E+07	2.85E+07											
	beta	1.41E+10	1.27E+10	1.27E+10	1.27E+10	1.27E+10											
	H-3	1.03E+12	9.18E+11	9.18E+11	9.18E+11	9.18E+11											
	Sr-90	1.03E+10	9.26E+09	9.26E+09	9.26E+09	9.26E+09											
	Cs-137	1.91E+11	1.71E+11	1.71E+11	1.71E+11	1.71E+11											
DFR POND	alpha	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07											
	beta	1.48E+10	2.90E+10	2.90E+10	2.90E+10	2.90E+10											
	H-3	5.52E+10	1.56E+10	6.38E+10	6.38E+10	6.38E+10											
	Sr90	5.00E+09	3.50E+09	3.15E+08	3.15E+08	3.15E+08											
	Cs137	2.50E+08	1.50E+06	8.99E+08	4.78E+07	4.78E+07											
DFR BFR	alpha			1.01E+07	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08	1.98E+08
	beta			1.54E+06	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11	1.63E+11
	H-3			1.32E+08	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09	2.59E+09
	Sr-90			3.63E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10	7.11E+10
	Cs-137			4.59E+09	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10	8.97E+10
DFR RNR	alpha																
	beta																
	H-3																
	Sr-90																
	Cs-137																
DFR Ops	alpha	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06
	beta	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11
	H-3	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11
	Sr-90	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09
	Cs-137	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10
TOTALS	alpha	5.38E+07	3.05E+07	6.06E+07	5.05E+07	2.29E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08
	beta	3.56E+11	3.14E+11	3.88E+11	3.43E+11	6.38E+11	4.45E+11	4.45E+11	4.45E+11	4.45E+11	4.45E+11	4.45E+11	4.45E+11	4.45E+11	4.45E+11	4.45E+11	4.45E+11
	H-3	1.19E+12	1.02E+12	1.03E+12	1.08E+12	1.02E+12	1.03E+12	1.03E+12	1.03E+12	1.03E+12	1.03E+12	1.03E+12	1.03E+12	1.03E+12	1.03E+12	1.03E+12	1.03E+12
	Sr-90	1.63E+10	1.03E+10	5.01E+10	1.06E+10	8.14E+10	7.21E+10	7.21E+10	7.21E+10	7.21E+10	7.21E+10	7.21E+10	7.21E+10	7.21E+10	7.21E+10	7.21E+10	7.21E+10
	Cs-137	2.11E+11	1.91E+11	1.96E+11	1.91E+11	2.81E+11	1.10E+11	1.10E+11	1.10E+11	1.10E+11	1.10E+11	1.10E+11	1.10E+11	1.10E+11	1.10E+11	1.10E+11	1.10E+11

### 3 Estimates of Discharges from the Prototype Fast Reactor (PFR)

3.1 The decommissioning of the PFR in the time period will encompass the following types of operations:

- Sodium residue removal – Reactor Vessel, SCTL, PCTL, IFC
- Disposal of 100Te sodium metal from KNK Germany
- Irradiated Fuel Cell (IFC) POCO operations
- Irradiated Fuel Buffer Store (IFBS) operations
- IFBS Pond water disposal
- Primary Sodium Pump and Intermediate Heat Exchanger cleaning
- Alkali Metals Laboratory operations
- Dismantling and steam clean of approximately 900 Boron Carbide (B<sub>4</sub>C) control rod pins
- Decontamination of reactor and IFC equipment and tools.

3.2 An extensive search and review of the documentation on PFR decommissioning has been carried out leading to a best estimate of radioactive waste inventory<sup>1</sup>. This best estimate considers the gaseous and liquid routes of disposal, allocating discharge to each media for each of the decommissioning activities.

3.3 One activity not captured by this review is the cleaning and disposal of the B<sub>4</sub>C control rods in the Irradiated Fuel Cell (IFC) steam clean facility. The control rods are to be broken down into cladding and B<sub>4</sub>C pellets. The cladding and pellets will then be steam cleaned to remove any residual sodium and stored as solid radioactive waste. These operations will result in an estimated release of 450 TBq of tritium at approximately 150 TBq/yr over a 3 year programme<sup>2</sup>.

- *The tritium inventory was based on the n2alpha reaction data quoted in the Brian Kelly<sup>3</sup> report on FR absorbers.*
- *Calculations were based on the irradiation history (i.e. effective full power days in PFR) to give the amount of tritium generated.*
- *The Kelly paper indicates that only about 30% of the tritium is retained in the boron carbide. The bulk would have found its way to the pellet surfaces via diffusion. As irradiation proceeds, the boron carbide pellets begin to crack and the fragments then progressively sub-divide due to internal mechanical stresses. The latter is due to the poor thermal conductivity of the boron carbide coupled with, to a lesser extent, tritium generation in the interstices of the boron carbide molecular structure. Thus, as irradiation proceeds the surface area of the boron carbide pellets increases and this, coupled with a high operating temperature allows gas diffusion to proceed at pace and tritium is released to the gas plenum and then the reactor coolant.*
- *In terms of operating temperature, it is worth noting that at reactor full power the centreline temperature of the boron carbide (i.e. ~1 cm diameter) is about 2500 degrees centigrade and outer temperature is about 700 degrees centigrade.*

---

<sup>1</sup> An Assessment of PFR Radionuclides at Decommissioning. PFR(05)P008

<sup>2</sup> Internal e:mail communication, B Munro to A Potts

<sup>3</sup> B T Kelly, Fast Reactor Systems Data and Conventions Manual: Materials Data for Neutron Absorbers, TRG Report 4000/5(S), FRDC/MWP(76)P244, FRASG(76)P44 - Rev

- On the basis of (3<sup>rd</sup> bullet) above, it is suggested that the inventory is circa 500Tbq of Tritium

3.4 Tritium discharges will be to both gaseous and liquid routes for which it is assumed the proportion to each will similar to that experienced for the PFR Secondary Sodium Cells decommissioning. Therefore 100% of the inventory is assumed to be discharged by the gaseous route whilst at the same time 10% of the inventory is discharged by the liquid route.

3.5 The krypton discharge, as ascribed to the Buffer Store, is declared at half the inventory held in the irradiated subassemblies currently stored in the Buffer Store Pond. The release arises from the storage cans being opened up to check the integrity of the containers. This operation could be carried out either within the Buffer Store or in the IFC. The release also assumes that up to half the containers have failed resulting in corrosion breach of the fuels primary containment resulting in a release of the krypton gas.

3.6 Uncertainty in the estimates of discharges results from;

- the lack of precision in the waste inventories;
- the assumptions made on the tritium inventory of B<sub>4</sub>C pins; and
- the potential worst case assumption on the failure rate of Buffer Store containment cans.

3.7 For the gaseous discharge, as the PFR decommissioning project is made up of new processes, the alpha and beta estimates are doubled, the tritium is times 1.5 and the krypton is left as estimated.

3.7.1 Following review of the estimates, the Krypton-85 limit has been reduced from 5.69E+14 Bq to 5.25E+14 Bq (see table below) in order to accommodate the need for a Krypton-85 limit for the FCA main stack (D1213).

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)	Revised Estimate (Bq/yr)	Revised Proposed Contribution to Site (Bq/yr)
Alpha	6.40E+04	1.28E+05	6.40E+04	1.28E+05
Beta (Excluding tritium and krypton-85)	3.87E+08	7.80E+08	3.87E+08	7.80E+08
Tritium	5.00E+13	7.50E+13	5.00E+13	7.50E+13
Krypton-85	5.69E+14	5.69E+14	5.25E+14	5.25E+14

- 3.8 For the liquid discharge, as the PFR decommissioning project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimates are doubled and the caesium and sodium are doubled;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	4.10E+07	8.20E+07
Beta (ex H-3)	6.70E+11	1.34E+12
H-3	5.00E+13	1.00E+14
Cs-137	3.05E+11	6.10E+11
Na-22	6.61E+09	1.32E+10

**PFR T1 – ESTIMATES OF GASEOUS DISCHARGES FROM THE PROTOTYPE FAST REACTOR PROJECT**

Predicted future 12 month discharge (Bq)																
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Tank Farm	trit 1.00E+07	1.00E+07														
SCTL	trit 5.00E+13	5.00E+13														
DDT	trit 3.75E+10					3.75E+10										
PCTL	alpha															
	beta															
	trit					8.49E+11	8.49E+11	8.49E+11								
SID	trit 8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09						
IFC residue	alpha															
	beta															
	trit	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09						
Reactor residue	alpha															
	beta		3.86E+08	3.86E+08	3.86E+08	3.86E+08	3.86E+08	3.86E+08								
	trit		2.89E+10	2.89E+10	2.89E+10	2.89E+10	2.89E+10	2.89E+10								
IFC POCO	alpha															
	beta															
	trit					3.00E+11	3.00E+11	3.00E+11								
IFBS Operations	alpha	4.00E+03	4.00E+03	4.00E+03	4.00E+03	4.00E+03	4.00E+03	4.00E+03								
	beta	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04								
	Kr-85	5.25E+14	5.25E+14	5.25E+14	5.25E+14	5.25E+14	5.25E+14	5.25E+14								
ANIL	alpha	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04								
	beta	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05								
	trit	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09								
TOTALS	alpha	6.40E+04	6.40E+04	6.40E+04	6.40E+04	6.40E+04	6.40E+04	6.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	beta	5.60E+05	5.60E+05	3.87E+08	3.87E+08	3.87E+08	3.86E+08	3.86E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	trit	9.14E+09	1.70E+10	5.00E+13	4.59E+10	1.19E+12	1.23E+12	1.20E+12	1.60E+10	1.60E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Kr-85	5.25E+14	5.25E+14	5.25E+14	5.25E+14	5.25E+14	5.25E+14	5.25E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

PFR T2 – ESTIMATES OF LIQUID DISCHARGES FROM THE PROTOTYPE FAST REACTOR PROJECT

Predicted future 12 month discharge (Bq)		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Tank Farm	trit	2.80E+07	2.80E+07														
SCTL	trit			5.00E+13	5.00E+13												
DDF	trit							3.75E+10	3.75E+10								
PCTL	alpha						1.76E+04	1.76E+04	1.76E+04								
	beta(ex H3)						1.25E+11	1.25E+11	1.25E+11								
	trit						8.49E+11	8.49E+11	8.49E+11								
	Cs-137						1.08E+11	1.08E+11	1.08E+11								
	Na-22						3.70E+06	3.70E+06	3.70E+06								
SID	trit	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09						
IFBS operations	alpha	5.40E+04	5.40E+04	5.40E+04	5.40E+04	5.40E+04	5.40E+04										
	beta(ex H3)	3.96E+08	3.96E+08	3.96E+08	3.96E+08	3.96E+08	3.96E+08										
	Trit																
	Cs-137																
IFC residue	alpha	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05						
	beta	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07						
	trit	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09						
Reactor residue	alpha					3.52E+06	3.52E+06	3.52E+06									
	beta(ex H3)					1.88E+11	1.90E+11	1.90E+11									
	trit					8.84E+11	8.84E+11	8.84E+11									
	Cs-137					1.54E+11	1.54E+11	1.54E+11									
	Na-22					6.61E+09	6.61E+09	6.61E+09									
IFC POCO	alpha					3.10E+06	3.10E+06	3.10E+06	3.10E+06	3.10E+06	3.10E+06						
	beta(ex H3)					6.36E+08	6.36E+08	6.36E+08	6.36E+08	6.36E+08	6.36E+08						
	trit					3.00E+11	3.00E+11	3.00E+11	3.00E+11	3.00E+11	3.00E+11						
Old LAET	alpha	1.52E+07	1.52E+07														
	beta	7.60E+08	7.60E+08														
	Cs-137	1.41E+07	1.41E+07														





#### 4 Gaseous Discharges from Facilities Elsewhere on Site

- 4.1 The radioactive gaseous discharges across the facilities on the site are currently grouped into six DSRL groupings/RSA Certificate Schedule tables:
- Fuel Cycle Area Main Stack/Table 4.4 (the 55m D1213 stack serving the ventilation of the majority of the Fuel Cycle Area plants and including the DMTR complex);
  - West Minor Sources/Table 4.5 (all radiological facility stacks between the DFR and PFR complexes); and
  - East Minor Sources/Table 4.6 (all radiological facility stacks East of the DFR complex).

4.2 The D1213 stack serves as the discharge conduit for the following facilities.:

- D1203 – Fuels processing and recovery;
- D1204 – ex Materials Test Reactor Fuels processing;
- D1205 – Laundry;
- D1206 – ex Fast Reactor Fuels reprocessing;
- D1207 – Store;
- D1208 – High Active Liquid waste storage and conditioning;
- D1215 and D1218 – High activity and Plutonium chemistry laboratories;
- D1217 – ex Post Irradiation Examination (PIE) facility;
- D1231 – Store;
- D1234 – Evaporator;
- D2001 – ILW waste handling and PIE cells; and
- D2700 – Cementation plant.

These facilities feed into the D1209 ventilation duct for final discharge via the D1213 stack

- D1250 – Dounreay Materials Test Reactor (DMTR) building; and
- D9814 and D8571 – The DMTR fuels storage pond and the PIE caves.  
These facilities feed into a ventilation link duct directly feeding into the D1213 stack.

The D1213 stack and the D1209 duct are to be replaced by October 2009. After completion of the change over of the ventilation systems the discharge estimates will have to be re-assessed to ensure that the limits requested in the 2009 application continue to be applicable.

- 4.2.1 Each facility's discharge is sampled for alpha and beta activity and, where appropriate, for tritium activity. The 12 month average discharge for alpha and beta, from the contributing facilities to D1213, is of the order of 1/2 orders of magnitude less than the 2008 12 month average for the statutory samples for the D1213 stack. This discrepancy is a function of measurements for D1213 at or very close to the minimum detectable activity (MDA) for each of the measured nuclides or groups of nuclides and/or pick up of activity from the common duct which is known to be contaminated.

- 4.2.2 In the years 2010 to 2015 it is estimated that the alpha and beta discharge will increase to a level above the MDA. This is due to the work to be carried out in D1206, D1234 and D1204. However the tritium and iodine will, in the same period remain below the MDA. The krypton activity is estimated from the known activity held within the fuel elements that will be treated in the period.
- 4.2.3 The D1213 stack discharge estimates are taken as the estimated facility discharges for alpha and beta.
- 4.2.4 The D1213 stack discharge estimates for tritium are taken as the upper range of the MDA.
- 4.2.5 The D1213 stack discharge estimates for iodine is as the extant authorised limit, taken as the upper range of the MDA.
- 4.3 For the gaseous discharge, the alpha and beta estimates are doubled to account for new decommissioning , the tritium and iodine-129 are set at a level commensurate with the analytical limit of detection.
- 4.3.1 Review of the original estimates has identified changes in the D1213 alpha and beta estimates (see table below). However, with the exception of Krypton-85 they do not require an increase in the corresponding D1213 limits (proposed contributions) originally requested.
- 4.3.2 An estimate has now been included for Krypton-85 to account for all Krypton-85 sources in FCA facilities that discharge to the FCA main stack (now replaced by FCA north and south stacks). The total Krypton-85 inventory has been calculated as 43.6 TBq. Inclusion of a Krypton-85 estimate and limit for D1213 does not affect the site Krypton-85 limit (proposed contribution) originally requested, as the PFR limit has been reduced accordingly to accommodate this.

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)	Revised Estimate (Bq/yr)	Revised Proposed Contribution to Site (Bq/yr)
<b>H-3</b>	5.13E+11	5.13E+11	5.13E+11	5.13E+11
<b>I-129</b>	1.00E+09	1.00E+09	1.00E+09	1.00E+09
<b>Beta (Excluding Tritium )</b>	7.28E+08	1.46E+09	4.39E+06	1.46E+09
<b>Alpha</b>	3.24E+06	6.48E+06	3.17E+06	6.48E+06
<b>Kr-85</b>	-	-	4.36E+13	4.36E+13

**D1213 T1 – ESTIMATES OF GASEOUS DISCHARGE FROM CONTRIBUTORY PLANTS**

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
D1203	alpha	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	3.00E+06	3.00E+06	3.00E+06	4.50E+04	4.50E+04	4.50E+04	
	beta	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	4.00E+06	4.00E+06	4.00E+06	5.50E+04	5.50E+04	5.50E+04	
D2580	alpha	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	
	beta	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	
D1231	alpha	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	
	beta	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	
D1204	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	
	beta	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	
	H-3	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+05						
D1205	alpha	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+09						
	beta	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04							
D1206	alpha	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	
	beta	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	
D1207	alpha	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	
	beta	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04							
D1208	alpha	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03
	beta	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04
D1217	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03							
	beta	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04							
D1234	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	
	beta	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	
D2001	alpha	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	
	beta	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	
	Kr-85	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	4.36E+13	
D2700	alpha	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04
	beta	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
D1250	alpha	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	
	beta	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	
	H-3	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	
D1251	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	
	beta	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04



4.4 The East Minor Sources (EMS) is a grouping of facilities, as set out in the extant authorisation table 4.6, that discharge radioactivity to atmosphere via various dedicated stacks of varying heights. The grouping comprises all stacks (excluding D1213) that are East of the DFR facility:

- D1200 – D1200 laboratories and D1215 space extract and fumehoods
- D1226 – D1200 laboratories
- D2670 – Marshall laboratory excluding the pulse column glovebox
- DN141 – Marshall laboratory pulse column glovebox
- D2900 – Decontamination facility
- D6499 – Low Level Waste pits repackaging facility
- D8570 – Waste Receipt Assay Characterisation and Super compaction facility
- D9867 – High alpha low beta/gamma waste store
- DN060 – Waste Compliance facility

4.4.1 An estimate of continuing discharge has been made for each of the facilities. The estimate was derived essentially from the high end of potential discharge with the following exceptions:

- D2900 tritium discharge which is based on potential discharge from decontamination of large items from PFR and DFR; and
- DNO60 discharges.

4.4.2 With the exception of D1200 alpha and D2900 and DN060 all measured discharges are at or very close to the MDA. D1200 alpha has on occasion been measured as a ‘real’ discharge and this is reflected in the higher estimate in all future years.

4.4.3 A further estimate of 1.00E+10 Bq tritium has been made to account for potential tritium release from DN060 should it be required.

4.5 The D1200 alpha, D2900 and DN060 beta and D2900 tritium estimates are doubled to allow for laboratory dismantling and new operations at DN060 and D2900.

4.5.1 Review of the original estimates identified a need to slightly increase the alpha and beta (excluding tritium and krypton-85) estimates (see table below). However, these changes do not require an increase to the corresponding East Minor Stack Grouping limits (proposed contributions) originally requested.

Radionuclide	Estimate (Bq/yr)	Revised Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
<b>H-3</b>	1.00E+10	1.00E+10	2.00E+10
<b>Kr-85</b>	4.00E+12	4.00E+12	4.00E+12
<b>Beta (Excluding Tritium and Krypton – 85)</b>	8.30E+05	8.40E+05	1.70E+06
<b>Alpha</b>	1.83E+05	1.93E+05	3.70E+05



**EMS T1 - ESTIMATES OF GASEOUS DISCHARGES FROM THE EAST MINOR SOURCES**

EAST MINOR SOURCES Predicted future 12 month discharges (Bq)		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
D1200 (includes D1215/18)	alpha	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04							
	beta	1.50E+05	1.50E+05	1.50E+05	1.50E+05	1.50E+05	1.50E+05	1.50E+05	1.50E+05	1.50E+05							
D1226	alpha	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04							
	beta	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05							
D2900	alpha	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04		
	beta	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05		
	H-3	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10		
D8570	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03		
	beta	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04		
D8867	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03							
	beta	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04							
D2670	alpha	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	
	beta	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	
	Kr-85	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	
DN141	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	
	beta	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	
Total	alpha	1.93E+05	1.93E+05	1.93E+05	1.93E+05	1.93E+05	1.93E+05	1.88E+05	1.88E+05	1.88E+05	1.88E+05	1.08E+05	1.08E+05	1.08E+05	1.08E+05	6.30E+04	6.30E+04
	beta	8.40E+05	8.40E+05	8.40E+05	8.40E+05	8.40E+05	8.40E+05	8.30E+05	8.30E+05	8.30E+05	4.80E+05	4.80E+05	4.80E+05	4.80E+05	4.80E+05	3.70E+05	3.70E+05
	H-3	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10		

4.6 The West Minor Sources (WMS) is a grouping of facilities, as set out in the extant authorisation table 4.5, that discharge radioactivity to atmosphere via various dedicated stacks of varying heights. The grouping comprises all stacks (excluding the PFR groups) that are West of the DFR facility:

- D3000 – Low Level Liquid Effluent Treatment Plant (LLETP), the final receipt of active liquor prior to discharge to the marine environment.
- D9833 – Ultrafiltration Pilot Plant, used to filter Silo liquor prior to discharge to LLETP
- D1115 – Storage of a full PFR Primary Cold Trap Loop filter.
- D2167 – Laundry for works clothing

4.6.1 The estimate of gaseous discharges from D3000 are held at the current values. These were the theoretical limits of detection used for the variation (V01) to the extant Certificate of Authorisation RSA/N/50010/99. There is considered to be no need to revise these in light of the recorded discharges.

4.6.2 The D9833 gaseous discharges have been reasonably constant for alpha and within one order of magnitude for beta depending on operation of the Ultrafiltration Plant.

4.6.3 The D1115 PCTL containment is regularly purged to provide assurance that the oxygen level in the containment is kept within preset values. The alpha and beta discharges are insignificant, generally being below 1 Bq per purge. The tritium discharge is however different in that if the sodium reacts with oxygen then a significant, in relation to the facility norm, release of tritium can occur. Thus an estimate has been made based on the previous discharges.

4.6.4 The D2167 Laundry estimates of gaseous discharge are based on the results obtained to date in the expectation that these will not differ significantly in the future.

4.7 For the gaseous discharge the alpha, beta and tritium estimates are as the estimates.

4.7.1 The original estimates for the West Minor Stack Grouping did not include those from the D1211 stack or the planned new laboratory stack. The revised estimates are included in the table below. Whilst these estimates exceed both the originally submitted estimates and limits for the West Minor Stack Grouping they only marginally increase the overall site estimates and do not affect the site limits (proposed contributions) originally requested.

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)	Revised Estimate (Bq/yr)	Revised proposed contribution to Site (Bq/yr)
Alpha	1.10E+04	1.10E+04	1.51E+05	2.61E+05
Beta	4.00E+04	4.00E+04	8.90E+05	1.39E+06
Tritium	1.01E+10	1.01E+10	1.11E+10	1.16E+10

**WMS T1 - ESTIMATES OF GASEOUS DISCHARGES FROM THE WEST MINOR SOURCES**

WEST MINOR SOURCES Predicted future 12 month discharges (Bq)		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Facility	Nuclide																
D3000	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03
	beta	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04
	H-3	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10
D9833	alpha	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03
	beta	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04
SILO	alpha	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	beta	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
D2167	alpha	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08
	beta	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03
D1211	alpha	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04
	beta	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04
D2176 (New Lab)	alpha	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05	2.40E+05
	beta	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06	1.30E+06
	H-3	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09	1.50E+09
Total	alpha	2.61E+05	2.61E+05	2.61E+05	2.61E+05	2.61E+05	2.60E+05	2.60E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05	2.50E+05
	beta	1.39E+06	1.39E+06	1.39E+06	1.39E+06	1.39E+06	1.38E+06	1.38E+06	1.33E+06	1.33E+06	1.33E+06	1.33E+06	1.33E+06	1.33E+06	1.33E+06	1.33E+06	1.33E+06
	H-3	1.16E+10	1.16E+10	1.16E+10	1.16E+10	1.16E+10	1.16E+10	1.15E+10	1.15E+10	1.15E+10	1.15E+10	1.15E+10	1.15E+10	1.15E+10	1.15E+10	1.15E+10	1.15E+10

LIQUID T1 - ESTIMATES OF LIQUID TRANSFERS TO THE LLETP

LIQUID DISCHARGES TO LAD (Bq)																	
Facility	Radionuclide	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
D1203	alpha	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+08	1.00E+08	1.00E+08	1.00E+08	2.50E+04	2.50E+04	
	beta	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	5.00E+09	5.00E+09	5.00E+09	5.00E+09	3.50E+04	3.50E+04	
D1209/13 Sump	alpha	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	5.00E+07						
	beta	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08						
D1208	alpha	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	
	beta	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	
D1200	alpha	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	
	beta	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	
D1204	alpha	2.00E+08	2.00E+08	1.00E+04	1.00E+04	1.00E+04											
	beta	9.00E+10	9.00E+10	1.00E+05	1.00E+05	1.00E+05											
	Sr-90	6.50E+10	6.50E+10														
	Cs-137	6.00E+10	6.00E+10														
	H-3	8.33E+10	8.33E+10	8.33E+10	8.33E+10	8.33E+10											
D1205	alpha	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
	beta	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
D2167	alpha	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	
	beta	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	
D1236	alpha	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	
	beta	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	
D1207	alpha	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05											
	beta	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06											
	Cs-137	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06											
D1215/18	alpha	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	
	beta	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	1.50E+08	
D1225/24	alpha	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	
SHAFT	beta	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	
	Sr-90	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	
	Cs-137	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	
D1234	alpha	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	



## 6 CONCLUSIONS

- 6.1 There are uncertainties in the estimates of future discharge ranging from moderate to significant. Where the uncertainty is moderate it is generally associated with ongoing processes that have historically returned reasonably constant discharges or sampling is able to provide reasonable confidence to the estimate. Where the uncertainty is significant it is generally associated with new processes (e.g. NaK destruction), where analytical results are sparse or the process has historically returned discharge results of the order of the analytical limit of detection.
- 6.2 Taking the uncertainties into account it is possible to adjust the estimates to allow flexibility whilst maintaining control and sum these estimates to provide an overall proposed site limit for both gaseous and liquid discharges.
- 6.3 The gaseous estimates are amended to provide the proposal in Site Gaseous T1:
- West Minor Sources(as defined):- For the gaseous discharge the alpha, beta and tritium estimates are unchanged;
  - East Minor Sources (as defined):- For the gaseous discharge the D1200 alpha, D2900 and DN060 beta and D2900 tritium estimates are doubled to allow for laboratory dismantling and new operations at DN060 and D2900;
  - FCA:-For the gaseous discharge, the alpha and beta estimates are doubled to account for new decommissioning , the tritium and iodine-129 are set at a level commensurate with the analytical limit of detection and the krypton-85 is left at the estimate;
  - DFR:- For the gaseous discharge, as the project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimated for the NDP project is doubled and the krypton is left as estimated; and
  - PFR estimates are doubled, as the project is made up of new processes, except for krypton which is left as estimated.

### SITE GASEOUS T1

#### PROPOSED ATMOSPHERIC DISCHARGE LIMITS As Per Extant Groupings

Nuclide	Authorisation Schedule 4 Table	4.4	4.2 & 4.7	4.3	4.6	4.5	Site Proposed Need Bq/yr
<b>alpha</b>		6.48E+06	1.28E+05	3.00E+05	3.70E+05	1.10E+04 (2.61E+05)	<b>7.28E+06</b>
<b>beta</b>		1.46E+09	7.80E+08	7.00E+08	1.70E+06	4.00E+04 (1.39E+06)	<b>2.94E+09</b>
<b>H-3</b>		5.13E+11	7.50E+13	2.70E+12	2.00E+10	1.01E+10 (1.16E+10)	<b>7.82E+13</b>
<b>Kr-85</b>		0.00E+00 (4.36E+13)	5.69E+14 (5.25E+14)	3.00E+12	4.00E+12	0.00E+00	<b>5.76E+14</b>
<b>I-129</b>		1.00E+09	-	-	-	-	<b>1.00E+09</b>

Following review of the original estimates the only stack groupings that require an increase are the FCA main stack and the West Minor Sources (Authorisation Schedule Tables 4.4. and 4.5 respectively in Site Gaseous Table T1 above).

The revised Krypton-85 limit of 4.36E+13 Bq for the FCA main stack (D1213) is presented in brackets, but does not necessitate an increase in the overall site limits, as the inclusion of a Krypton-85 limit has been accommodated by reducing the PFR stack group Krypton-85 limit from 5.69E+14 Bq to 5.25E+14 Bq.

The revised limits for the West Minor Sources stack grouping are presented in brackets, but do not necessitate an increase in the overall site limits. Note that the increased alpha limit of 2.61E+05 Bq for the West Minor Sources stack grouping (Table 4.5) results in the individual stack grouping alpha limits totalling slightly more than the originally stated proposed site need of 7.28E+06 Bq. However, there is no need to increase the site proposed need, as there is sufficient headroom in the other stack group limits, principally the FCA main stack (Table 4.4).

6.4 The liquid estimates are amended to provide the proposal in Site Liquid T1:

- DFR:- For the liquid discharge, as the project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimated for the NDP project is doubled and the caesium 137 and strontium 90 are doubled;
- PFR:- For the liquid discharge, as the project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimates are doubled and the caesium 137 and the sodium 22 are doubled;
- Other contributors:- For the liquid discharge, the alpha is increased by a factor of 1.5 and rounded down, beta has the strontium 90 (principal source is the shaft) subtracted and the remainder is increased by a factor of 1.5. The tritium, Caesium 137, Strontium 90 and Americium 241 are each increased by a factor of 1.5.

**SITE LIQUID T1**

Proposed Limits (Liquid Discharge)

	<b>DFR Proposed Limit (Bq/yr)</b>	<b>PFR Proposed Limit (Bq/yr)</b>	<b>Rest of Site Proposed Limit (Bq/yr)</b>	<b>Site Proposed Need (Bq/yr)</b>
Total alpha	4.00E+08	8.20E+07	3.19E+09	3.67E+09
Total beta (Excl. tritium)	1.26E+12	1.34E+12	1.26E+11	2.73E+12
Total Sr-90	1.47E+11	-	1.28E+11	2.74E+11
Total Cs-137	5.60E+11	6.10E+11	9.81E+10	1.27E+12
Total Na-22	-	1.32E+10	-	1.30E+10
Total H-3	2.40E+12	1.00E+14	(1.25E+11)	1.02E+14
Total Am-241	-	-	1.50E+07	1.50E+07

**Following review of the original estimates the only proposed limit that has been altered is 'rest of site' tritium. The revised limit is presented in brackets, but does not necessitate an increase in the overall site limit for tritium.**