Radioactive Substances Series

Liquid Discharges from Nuclear Installations in 2005, including exceptional discharges from decommissioning and management of legacy radioactive wastes

OSPAR Commission
2007

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

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Executive summary/*Récapitulatif*

This annual report includes the data of 2005 on liquid radioactive discharges from nuclear installations and covers the period 1990-2005. On this basis, an assessment has been made for the discharges from nuclear power stations, nuclear fuel reprocessing plants, nuclear fuel fabrication and enrichment plants, and research and development facilities. It covers total alpha, tritium and total beta activity (excluding tritium) in TBq/y for each type of nuclear installation. To facilitate comparison of the discharges year by year temporal trends are shown for total alpha, tritium and total beta (excluding tritium) for the period 1990-2005.

Le présent rapport annuel comprend les données de 2005 sur les rejets radioactifs liquides des installations nucléaires, et couvre la période de 1990 à 2005. Sur cette base, les rejets des centrales nucléaires, des usines de retraitement du combustible nucléaire, des installations de fabrication et d'enrichissement du combustible nucléaire, ainsi que des équipements de recherche et développement ont été évalués. Cette évaluation porte sur l'activité alpha totale, le tritium et l'activité bêta totale (à l'exclusion du tritium) exprimés en TBq/an pour chacun des secteurs des installations nucléaires. Pour faciliter la comparaison des rejets d'une année à l'autre, les tendances chronologiques d'alpha total, du tritium et de bêta total (à l'exclusion du tritium) sont mises en évidence pendant la période de 1990 à 2005.

There is a downward trend in the amount of total-alpha activity discharged from all nuclear installations over the 15-year period. However, discharges of alpha activity between 2002 and 2005 were higher than over the period 1997 – 2000, largely as a result of higher total-alpha releases from the reprocessing plant at Sellafield. In 2004 and 2005, the discharges from Sellafield were lower than those in 2003. It is expected that this downturn will continue. A further significant contributor to the summed discharges is from the fuel fabrication plant at Springfields. Discharges from research and development facilities were very low in 2002, with an increase in 2003 and a further reduction in 2004 and in 2005.

On constate une tendance à la baisse de l'activité alpha totale rejetée par toutes les installations nucléaires sur la période de 15 ans en cause. Toutefois, les rejets d'activité alpha de 2002 à 2005 se sont avérés plus importants que sur la période 1997-2000, en grande partie en raison de l'augmentation des émissions d'alpha total de l'usine de retraitement de Sellafield. En 2004 et en 2005, les rejets de Sellafield étaient inférieurs à ceux de 2003. On s'attend à ce que ce début de tendance à la baisse se poursuive. Un autre contributeur important à la somme des rejets est l'installation de fabrication de combustible de Springfields. Les rejets des équipements de recherche et de développement étaient très faibles en 2002. Cependant, ils se sont avérés plus importants en 2003, suivis d'une reduction en 2004 et en 2005.

The tritium releases from all installations increased in the period from 1996 – 2005, which is mainly due to the discharges from La Hague. The reprocessing plants in La Hague and Sellafield contribute, in aggregate, to approximately 78 % of the overall discharges. Discharges of tritium from nuclear power stations and research and development facilities show slowly increasing values over the period 2000 – 2005. The contribution of the research and development facilities is very low.

Les rejets de tritium de toutes les installations ont augmenté sur la période de 1996 à 2005, augmentation essentiellement due aux rejets de l'usine de La Hague. Regroupées, les usines de retraitement de La Hague et de Sellafield représentent environ 78 % de l'ensemble des rejets. On constate une fluctuation légère à la hausse des rejets de tritium des centrales nucléaires et des équipements de recherche et développement sur la période de 2000 à 2005. La contribution des installations de recherche et développement est très faible.

The sum of total-beta activity (excluding tritium) from all nuclear installations has fallen significantly over the past 15 years. Total emissions are dominated by discharges from the nuclear fuel plant at Springfields and to a lesser extent the reprocessing plant at Sellafield. The two installations together contribute approximately 98 % of the overall discharges. The high, but decreasing total-beta discharges from Sellafield are mainly attributable to the radionuclide Technetium-99. The reduction of Sellafield's total-beta discharges from 2002 to 2005 is a result of the significant reduction in Technetium-99 discharges, due to the vitrification process, since 1994 for oxide fuels and 2003, for magnox fuels. Discharge of Tc-99 to sea (primarily from treatment of stored Magnox wastes) has been reduced between 1994 and 2005.

A l'exclusion du tritium, la somme d'activité beta totale de toutes les installations nucléaires a significativement baissé ces quinze dernières années. Les émissions de l'usine de retraitement du combustible nucléaire à Sellafield et l'installation de fabrication et d'enrichissement du combustible nucléaire de Springfields constituent les rejets totaux pour l'essentiel. Conjointement, ces deux équipements représentent environ 98% de l'ensemble des rejets. Les rejets élevés, mais décroissants, de bêta total de Sellafield sont surtout imputables au radionucléide technétium 99. La baisse des rejets de bêta total de l'usine de Sellafield, telle que survenue pendant la période de 2002 à 2005, résulte d'une réduction significative des rejets de Technétium 99, due à la procédure de vitrication en vigueur depuis 1994 pour le combustible oxyde, et 2003, pour le combustible Magnox. Les rejets de technétium 99 dans le milieu marin (plus particulièrement du traitement des rejets de Magnox stocké) ont baissé entre 1994 et 2005.

For the first time, discharges arising from decommissioning and the recovery and conditioning of legacy wastes are separately from operational nuclear discharges. The discharges from such activities are reported as "Exceptional Discharges" and appear in this report in a separate table.

Pour la première fois, les rejets émanant du déclassement et de la récupération et du conditionement des déchets antérieurs sont séparés des rejets provenant de l'exploitation de substances nucléaires. Les rejets de telles activités sont notifiés en tant que « Rejets exceptionnels » et se trouvent sous un autre tableau dans ce rapport.

1. Introduction

The possibility of harm to the marine environment and its users (including the consumers of food produced from the marine environment) from inputs of radionuclides caused by human activities was always a subject with which the 1972 Oslo and 1974 Paris Conventions were concerned – a concern taken over by the 1992 OSPAR Convention and taken forward in the work of implementing it. When the Paris Convention was adopted in 1974, in order to provide for international action against land-based sources of marine pollution, the Contracting Parties undertook "to adopt measures to forestall and, as appropriate, eliminate pollution of the maritime area from land-based sources by radioactive substances".

When the first Ministerial meeting under the 1992 Convention of the OSPAR Commission was held in 1998 at Sintra, Portugal, agreement was reach on a strategy to guide the future work of the OSPAR Commission on protecting the marine environment of the North-East Atlantic against radioactive substances arising from human activities. This strategy was revised and confirmed by the second Ministerial meeting of the OSPAR Commission at Bremen in 2003. The OSPAR Radioactive Substances Strategy thus now provides that:

> "In accordance with the general objective [of the OSPAR Convention], the objective of the Commission with regard to radioactive substances, including waste, is to prevent pollution of the maritime area from ionising radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances. In achieving this objective, the following issues should, inter alia, be taken into account:
>
> a. legitimate uses of the sea;
> b. technical feasibility;
> c. radiological impacts on man and biota."

The Strategy further provides that:

> "This strategy will be implemented in accordance with the Programme for More Detailed Implementation of the Strategy with regard to Radioactive Substances in order to achieve by the year 2020 that the Commission will ensure that discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emission and losses, are close to zero."

The Programme for More Detailed Implementation of the Strategy with regard to Radioactive Substances (the "RSS Implementation Programme") and the agreements made at the second OSPAR Ministerial meeting, in effect, provide that

a. the Contracting Parties will each prepare a national plan for achieving the objective of the Strategy;
b. they will monitor and report on progress in implementing those plans, and
c. the OSPAR Commission will periodically evaluate progress against an agreed baseline.

Regular reporting from Contracting Parties is therefore required in order to review progress towards this target.

1.1 Programmes and measures

Since the mid 1980s, liquid discharges of radioactive substances from nuclear installations have been addressed under the former Paris Convention (PARCOM) and under the OSPAR Convention. The following relevant measures[1] are applicable [2] under the OSPAR Convention:

- PARCOM Recommendation 88/4 on Nuclear Reprocessing Plants;
- PARCOM Recommendation 91/4 on Radioactive Discharges [3];

1 All measures referred to in this chapter can be downloaded from the OSPAR website www.ospar.org (under "measures").

2 OSPAR Decision 2000/1 is not strictly applicable to France and the United Kingdom since they abstained from voting.
OSPAR Decision 2001/1 is not strictly applicable to France, Switzerland and the United Kingdom since they abstained from voting.

3 The implementation of this Recommendation requires an assessment to be carried out as to whether BAT is being applied in nuclear installations. Contracting Parties submit national reports that also contain discharge data on a

- PARCOM Recommendation 93/5 Concerning Increases in Radioactive Discharges from Nuclear Reprocessing Plants;
- PARCOM Recommendation 94/8 Concerning Environmental Impact Resulting from Discharges of Radioactive Discharges [4];
- PARCOM Recommendation 94/9 Concerning the Management of Spent Nuclear Fuel [5];
- OSPAR Decision 2000/1 on Substantial Reductions and Elimination of Discharges, Emissions and Losses of Radioactive Discharges, with Special Emphasis on Nuclear Reprocessing;
- OSPAR Decision 2001/1 on the Review of Authorisations for Discharges or Releases of Radioactive Substances from Nuclear Reprocessing Activities;
- OSPAR RSC agreed at its Knokke meeting (RSC 2006) that discharges from “decommissioning and recovery of old waste” should be reported by Contracting Parties on a template referred to by RSC as “exceptional discharges”.

The OSPAR First Periodic Evaluation of the Progress in Implementing the OSPAR Radioactive Substances Strategy, published in 2006, has also informed this report.

1.2 Annual reporting

In 1985, Contracting Parties to the former Paris Convention initiated reporting on liquid discharges from nuclear installations. These data have subsequently been submitted annually by Contracting Parties and collated by the Secretariat and, following examination by the EAP, published by the Commission in the form of annual reports; at first as part of the Commission's general annual report, and from 1991 onwards in annual reports on discharges from nuclear sectors. From 1998 onwards, the annual reports (starting with 1996 data) also contain an assessment of liquid discharges which include a description of the trends from 1989 until the date of the latest report. The Commission also published in 1998 a summary of the report on sources, inputs and temporal trends of radioactive discharges from nuclear installations for the years 1989 to 1995 (ISBN 0 946955 85 9).

Over time, reporting requirements and formats for data collection as regards nuclear installations have been regularly reviewed and updated in the light of experience and ongoing work under the Commission. With a view to harmonising the way in which data and information are being established and reported, the OSPAR Commission adopted in 1996 the reporting format used for annual data up to 2005 (reference number: 1996-2).

RSC decided at the meeting in Knokke, in 2006, that for data from 2005 onwards, discharges arising from decommissioning and the recovery and conditioning of legacy wastes should be reported separately from operational nuclear discharges. The discharges from such activities were reported as “Exceptional Discharges” and appear in this report in a separate table.

1.3 Parameters monitored and reported

The tables in this annual report contain data on total alpha, total beta, tritium and individual radionuclides. The assessment in Chapter 2 and the Figures 1, 2 and 3 show trends in discharges of total alpha activity, total beta activity and tritium.

Total alpha and total beta values are useful as they will encompass the contribution to the overall activity from a wide range of radionuclides which, individually, would be difficult to measure or could be below detection limits. However, total alpha and total beta values provide limited information about the potential harm as such information should be based on the characteristics of individual radionuclides. Tritium is reported separately.

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regular basis thereby using the Guidelines for the submission of information about, and the assessment of, the application of BAT in nuclear facilities (reference number: 1999-11).

4 Assessments of the effect and relative contributions of remobilised historical discharges and current discharges of radioactive substances, including wastes, on the marine environment have been published in the Quality Status Report 2000 published by the OSPAR Commission in 2000 (ISBN 0 946956 52 9) and in the MARINA II Report published by the European Commission; see website: http://europa.eu.int/comm/environment/radprot/.

5 At the request of the OSPAR Commission in this Recommendation, the OECD Nuclear Energy Agency published in 2000 a comparative study on Radiological Impacts of Spent Nuclear Fuel Management Options (ISBN 92 64 17657 8).

There is currently little consistency in the approach adopted by Contracting Parties in the assessment of total alpha and total beta quantities. Consequently, for the purposes of this report total alpha quantities include measurements that are strictly gross alpha; similarly for total beta, quantities gross beta measurements are included.

Total alpha represents the measured radioactivity of alpha particle emitting radionuclides. These particles, that are composed of two protons and two neutrons, are emitted as a result of the decay of certain radionuclides, the so-called α-emitters. On average, the total liquid discharges of α-emitters from all nuclear sites represent mainly Pu-239, Pu-240 and Am-241 and, to a lesser extent, Th-230, Pu-238 and some other nuclides [6].

Total beta represents the measured radioactivity of beta particle emitting radionuclides. These particles, that are similar to electrons, except they originate from (processes within) the atomic nucleus, are emitted as a result of the decay of certain radionuclides, the so-called β-emitters. On average, the total liquid discharges of β-emitters from all nuclear sites represent mainly Ru-106, Sr-90, Pu-241, Cs-137, Tc-99 and, to a lesser extent, a range of other radionuclides. Total beta in this report excludes tritium, which is reported separately.

Tritium (H-3) is an isotope of hydrogen that emits low-energy radiation in the form of beta particles. Tritium is discharged from most nuclear power plants, reprocessing plants and some research and development facilities.

6 For abbreviations of radionuclides see Chapter 3.

2. Assessment of the liquid radioactive discharges from nuclear installations in 2005

Table 1 summarises liquid radioactive discharges from nuclear installations for the time period 1990 – 2005; data for 1990 – 2005 are taken from the OSPAR Annual Reports on Liquid Discharges from Nuclear Installations. Reported discharges include data from nuclear power stations, nuclear fuel reprocessing plants, nuclear fuel fabrication and enrichment plants and nuclear research and development facilities. For each type of nuclear installation, Table 1 gives total alpha activity, tritium and total beta activity excluding tritium in TBq/y as well as the ratio as a percentage of the total discharges from all installations. To facilitate comparison of the discharges year by year, Figures 1 to 3 show temporal trends of total alpha, tritium and total beta excluding tritium for the time period 1990 to 2005.

Both Table 1 and Figure 1 show a decrease of the total alpha activity discharged from all nuclear installations over the 15-year period. However, discharges of alpha activity in the period 2002 to 2005 were higher than over the period 1997 - 2000. The reason for this rise to 0,61 and 0,62 TBq in 2002 and 2003 respectively is largely a result of higher total alpha releases from the reprocessing plant at Sellafield, United Kingdom (2000: 0,12 TBq, 2002: 0,35 TBq, 2003: 0,41 TBq, 2004: 0,29 TBq, 2005: 0,25 TBq), although these have remained well within the authorised limit of 1TBq/yr. The discharges in 2004 and 2005 from Sellafield were lower than 2003, it is expected that this downturn will continue and that 2003 will clearly be seen as a peak that has now passed. A further significant contributor to the total discharges in 2005 was the fuel fabrication plant at Springfields (0,25 TBq), which in 2005 equalled the discharges from Sellafield. Discharges from research and development facilities have been very low and in the range 0,0016 – 0,0047 TBq in the period up to 2003 and have decreased further in 2005 and 2004 to 0,001 TBq.

Figure 2 presents the discharges of tritium, in terms of activity. The tritium releases from all installations increased from around 8000 TBq/y during the period 1990 - 1992 to discharges in the order of 15000 to 20000 TBq in the period 1996 - 2005. This increase is mainly due to the discharges from La Hague (2001: 9650 TBq, 2002: 12000 TBq, 2003: 11900 TBq, 2004: 13900 TBq, 2005: 13500 TBq). Tritium discharges from Sellafield show an apparent drop in 2005 to 1570 TBq from the range 3170 to 3900 in the period 200 to 2004.The reprocessing plants in La Hague and Sellafield contribute in total approximately 78 % (2005) of the overall discharges. Discharges of tritium from nuclear power stations show slowly increasing values over the time period 2000 – 2005. The contribution of the research and development facilities is very low (0,1 %). There is no pronounced temporal trend between 1995 and 2005.

Figure 3 shows that the sum of total beta activity (excluding tritium) from all nuclear installations has significantly decreased over the past 15 years, from 491 TBq (1990), down to 204 TBq in 2004 and has reduced further to 160 TBq in 2005. Total beta discharges are dominated by discharges from the nuclear fuel plant at Springfields and to a lesser extent the reprocessing plants. These installations together contribute approximately 98 % (2005) of the overall discharges. The total beta discharges from Sellafield (2002: 112 TBq, 2003: 83 TBq, 2004: 73 TBq, 2005: 43 TBq) were previously mainly attributable to the radionuclide Technetium-99 (2002: 85 TBq, 2003: 37 TBq, 2004 14 TBq, 2005: 6,7 TBq), for which abatement technology was installed in 2004. The reduction of Sellafield's total beta discharges in 2005 is due to the reduction of Technetium-99 (2004 14 TBq, 2005: 6,7 TBq), Carbon-14 (2004: 16 TBq, 2005: 5,3 TBq), Strontium-90 (2004: 18 TBq, 2005: 13 TBq), Ruthenium-106 (2004: 8,1 TBq, 2005: 1,8 TBq), Caesium-137 (2004: 9,7 TBq, 2005: 5,8 TBq) and Plutonium-241 (2004: 8,1 TBq, 2005: 5,5 TBq).

Table 1 - Summary of Liquid Radioactive Discharges of Nuclear Installations, 1990 – 2005

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
TOTAL ALPHA																
All Nuclear Installations (TBq)	2,43	2,43	1,83	2,88	1,36	0,68	0,57	0,38	0,43	0,42	0,33	0,41	0,61	0,62	0,54	0,52
Reprocessing Plants (TBq)	2,2	2,2	1,7	2,7	1,1	0,47	0,32	0,23	0,22	0,17	0,16	0,25	0,39	0,43	0,31	0,27
% of the alpha discharges	90,6	90,6	93,0	93,7	80,9	69,1	56,1	60,5	51,2	41,6	47,7	59,9	63,3	69,9	57,4	51,7
Nuclear Power Plants (TBq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% of the alpha discharges	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nuclear Fuel Fabrication (TBq)	0,21	0,15	0,10	0,08	0,16	0,12	0,12	0,12	0,20	0,24	0,17	0,16	0,22	0,18	0,23	0,25
% of the alpha discharges	8,6	6,2	5,4	2,8	11,8	17,6	21,1	31,6	46,5	57,7	51,7	39,7	36,3	29,9	42,5	48,1
R&D Facilities (TBq)	0,02	0,03	0,03	0,1	0,1	0,09	0,13	0,03	0,01	0,003	0,0019	0,0016	0,0021	0,0047	0,0005	0,001
% of the alpha discharges	0,8	1,2	1,6	3,5	7,3	13,3	22,8	7,9	2,3	0,7	0,6	0,4	0,3	0,7	0,1	0,2
TRITIUM																
All Nuclear Installations (TBq)	7224	8797	7658	10902	12931	15040	16779	17991	16240	18871	16548	15759	18880	19636	20634	19248
Reprocessing Plants (TBq)	4959	6513	4969	7460	9770	12310	13500	14500	12800	15420	13300	12221	15220	15800	17070	15070
% of the tritium discharges	68,6	74,0	64,9	68,4	75,6	81,9	80,5	80,6	78,8	82,1	80,4	77,5	80,6	80,5	82,7	78,3
Nuclear Power Plants (TBq)	2164	2252	2665	3354	3044	2713	3264	3440	3430	3335	3241	3543	3648	3819	3560	4160
% of the alpha discharges	30,0	25,6	34,8	30,8	23,3	18	19,5	19,1	21,1	17,8	19,6	22,5	19,3	19,4	17,3	21,6
Nuclear Fuel Fabrication (TBq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% of the tritium discharges	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R &D Facilities	101	32	23,7	87,9	117,5	16,7	15	16	14	16	7	5,8	11,6	18	3,6	18
% of the tritium discharges	1,4	0,4	0,3	0,8	0,9	0,1	0,09	0,1	0,1	0,1	0,04	0,04	0,06	0,09	0,02	0,1

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
TOTAL BETA																
All Nuclear Installations (TBq)	491	227	269	252	321	365	332	315	265	256	173	231	235	198	204	160
Reprocessing Plants (TBq)	384	178	134	170	195	243	169	167	112	126	98	141	125	97,3	86,4	54
% of the beta discharges	78,3	78,4	49,8	67,4	60,8	66,5	50,9	53,0	42,4	49,1	57,5	61,2	53,1	49,0	42,4	34,1
Nuclear Power Plants (TBq)	10,3	3,8	8,8	11,1	2,8	3,4	5,2	7,4	2,0	2,0	3,0	4,2	3,6	3,2	1,3	2,0
% of the beta discharges	2,1	1,7	3,3	4,4	0,9	0,9	1,6	2,3	0,8	0,7	1,7	1,8	1,5	1,6	0,6	1,3
Nuclear Fuel Fabrication (TBq)	92	38,9	120	63	114	112	150	140	150	128	71	85	106	97	116	103
% of the beta discharges	18,7	17,1	44,6	25	35,5	30,7	45,1	44,4	56,6	50,0	41,6	36,8	45,1	49,1	56,8	64,5
R&Dt Facilities (TBq)	4,5	6,3	6,6	8,2	9,1	7,0	8,1	1	0,66	0,36	0,30	0,46	0,46	0,44	0,47	0,09
% of the beta discharges	0,9	2,8	2,4	3,2	2,8	1,9	2,4	0,3	0,2	0,1	0,2	0,2	0,2	0,3	0,2	0,1

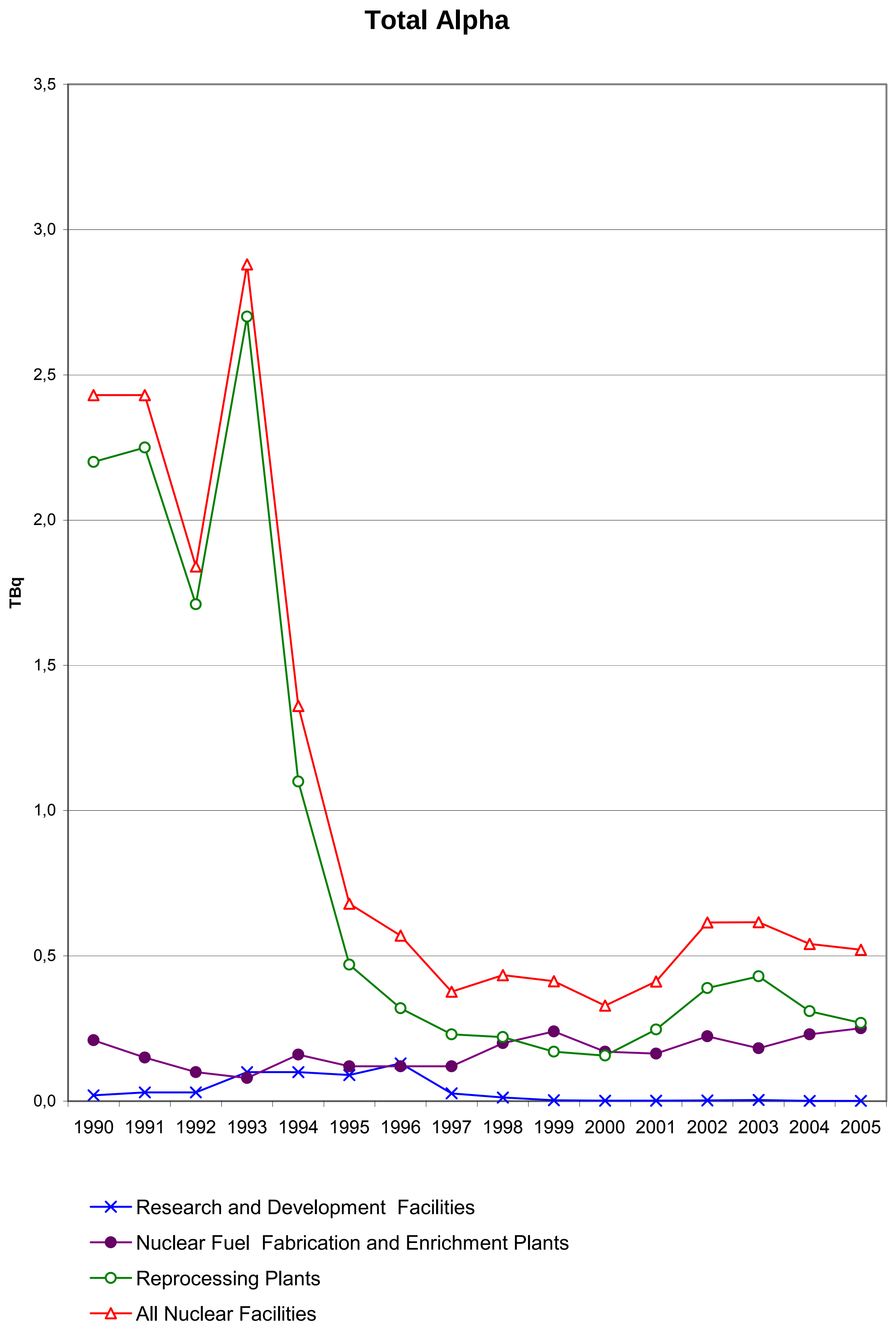

Figure 1 Annual releases of Total Alpha in liquid discharges from all nuclear installations in contracting parties to the OSPAR Convention, 1990 – 2005

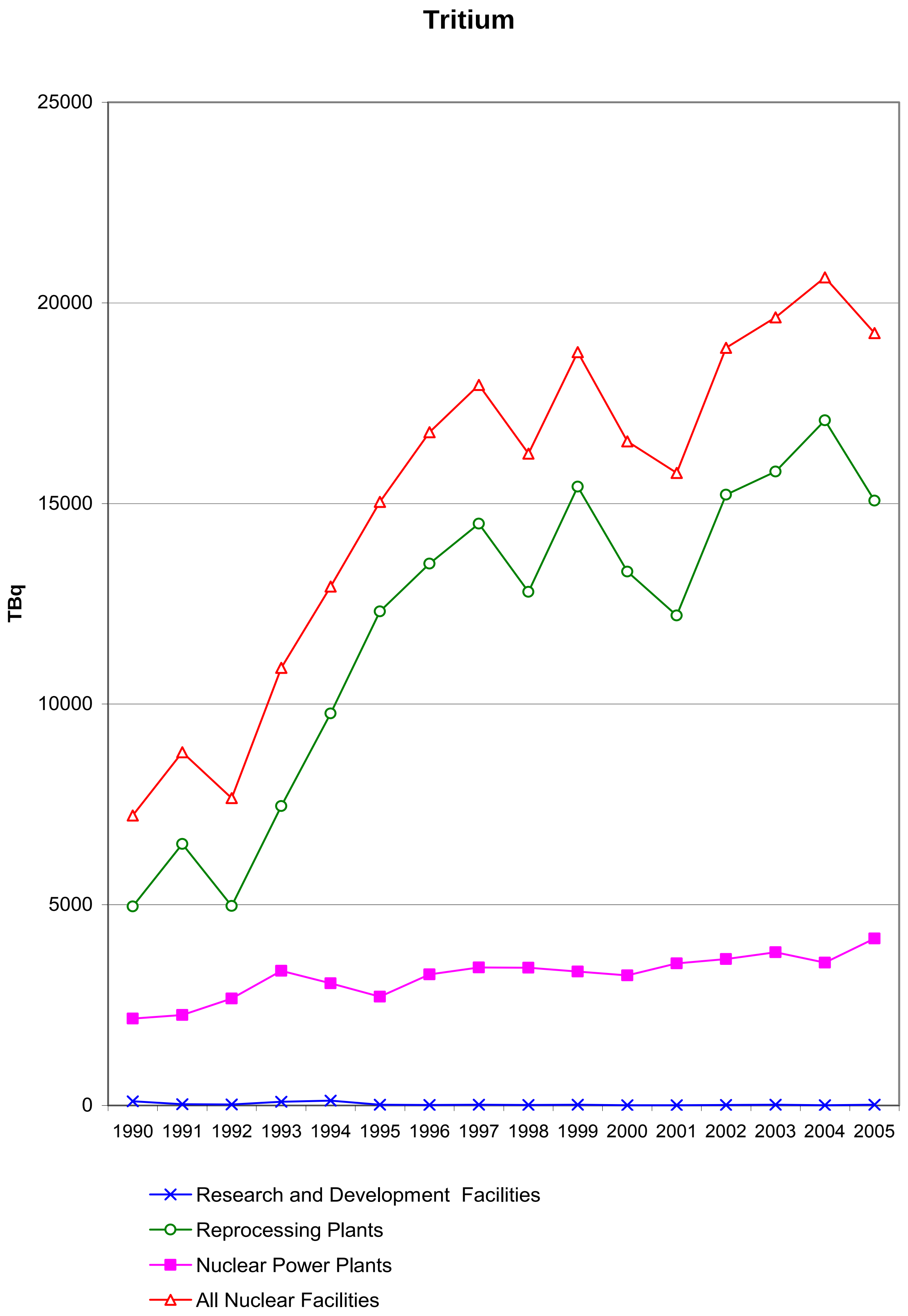

Figure 2 Annual releases of Tritium in liquid discharges from all nuclear installations in Contracting Parties to the OSPAR Convention, 1990 – 2005

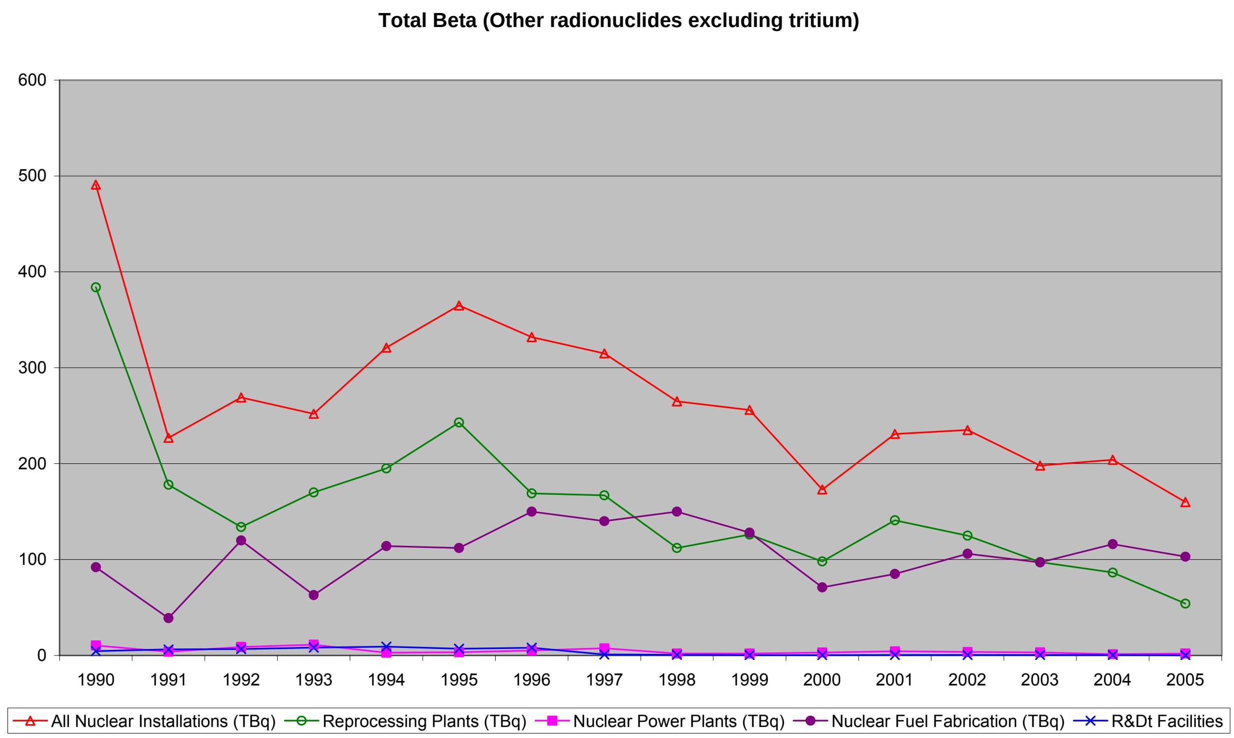

Figure 3 Annual releases of Total Beta in liquid discharges from all nuclear installations in Contracting Parties to the OSPAR Convention, 1990 - 2005

3. 2005 Data and Information

In this chapter of the report, data and information on liquid discharges is presented for each Contracting Party under the following categories of nuclear installations draining into the OSPAR maritime area:

Table 2: Nuclear Power Stations;

Table 3: Nuclear Fuel reprocessing Plants;

Table 4: Nuclear Fuel Fabrication and Enrichment Plants;

Table 5: Research and Development Facilities.

Further detailed information with respect to individual plants is presented in endnotes after the entire set of tables.

The columns, headings and abbreviations used in the tables correspond to the reporting requirements set out in the current reporting format. The following abbreviations are used in the tables:

AGR: Advanced Gas Cooled Reactor;

GCR: Gas Cooled Reactor;

UNGG: Natural Uranium Gas Graphite (French equivalent for GCR);

PWR: Pressurised Water Reactor;

THTR: Thorium High Temperature Reactor;

BWR: Boiling Water Reactor;

NA: Not applicable;

NI: No information;

ND: Not detectable.

For radionuclides:

Ag:	Silver	Gd:	Gadolinium	Rh:	Rhodium
Am:	Americum	I:	Iodine	Ru:	Ruthenium
Ba:	Barium	Mn:	Manganese	S:	Sulphur
Be:	Beryllium	Na:	Sodium	Sb:	Antimony
C:	Carbon	Nb:	Niobium	Se:	Selenium
Ce:	Cerium	Ni:	Nickel	Sr:	Strontium
Cm:	Curium	Np:	Neptunium	Tc:	Technetium
Co:	Cobalt	Pm:	Promethium	Th:	Thorium
Cr:	Chromium	Pr:	Praseodymium	U:	Uranium
Cs:	Caesium	Pu:	Plutonium	Y:	Yttrium
Eu:	Europium	Ra:	Radium	Zn:	Zinc
Fe:	Iron	Rb:	Rubidium	Zr:	Zirconium

All data on discharge limits and releases of radionuclides have been entered in the tables using continental decimal system. The data values are expressed in scientific number format, e.g. 0,0009 as 9,0E-04.

3.1 Locations of nuclear installations

The location and type of each installation is listed in the table below.

Country / Code	Name installation	Type	Discharging into
Belgium			
B1	Doel	NPS	Schelde
B2	Tihange	NPS	Meuse
B3	Mol	RDF	River Mol-Neet
Denmark			
DK1	Risø	RDF	Kattegat through Roskilde Fjord
France			
F1	Belleville	NPS	Loire
F2	Cattenom	NPS	Mosel
F3	Chinon	NPS	Loire
F4	Chooz	NPS	Meuse
F5	Civaux	NPS	Vienne
F6	Dampierre en-Burly	NPS	Loire
F7	Fessenheim	NPS	Rhine
F8	Flamanville	NPS	Channel
F9	Fontenay-aux- Roses	RDF	Seine
F10	Golfech	NPS	Garonne
F11	Gravelines	NPS	North Sea
F12	Le Blayais	NPS	Gironde Estuary
F13	La Hague	NFRP	English Channel
F14	Nogent-sur-Seine	NPS	Seine
F15	Paluel	NPS	Channel
F16	Penly	NPS	Channel
F17	Saclay	RDF	Etang de Saclay
F18	Saint Laurent	NPS	Loire
Germany			
D1	Biblis A/Biblis B	NPS	Rhine
D2	Brokdorf	NPS	Elbe
D3	Brunsbüttel	NPS	Elbe
D4	Grafenrheinfeld	NPS	Main
D5	Grohnde/Emmerthal	NPS	Weser
D6[7]	Hamm-Uentrop	NPS	Lippe
D7	Kahl	NPS	Main
D8	Krümmel/Geesthacht	NPS	Elbe
D8	Geesthacht	RDF	Elbe
D9	Lingen/Emsland	NPS	Ems
D9	Lingen	NFFEP	Ems - via municipal sewer system
D10	Mülheim-Kärlich	NPS	Rhine
D11	Neckar- westheim 1/Neckar-wesheim 2	NPS	Neckar
D12	Obrigheim	NPS	Neckar
D13	Philippsburg KKP1/ Philippsburg KKP2	NPS	Rhine
D14	Rheinsberg	NPS	Havel
D15	Stade	NPS	Elbe
D16	Rodenkirchen-Unterweser	NPS	Weser
D17	Würgassen/Beverungen	NPS	Weser
D18	Karlsruhe	RDF	Rhine

[7] D6 was shut down.

Country / Code	**Name installation**	**Type**	**Discharging into**
D19	Gronau	NFFEP	Vechte, IJsselmeer
D20	Hanau	NFFEP	Main - via municipal sewer system
D21[8]	Karlstein	NFFEP	Main - via municipal sewer system
D22	HMI Berlin	RDF	Havel
D23	Jülich	RDF	Rur
D24	Rossendorf	RDF	Elbe
The Netherlands			
NL1	Borssele	NPS	Scheldt Estuary
NL2	Doodewaard	NPS	Waal
NL3	Almelo	NFFEP	Municipal sewer system
NL4	Delft	RDF	Sewage system
NL5	Petten	RDF	North Sea
Norway			
N1	Halden	RDF	River Tista (Skagerrak)
N2	Kjeller	RDF	River Nitelva (Skagerrak)
Portugal			
P1	Campus de Sacavém	RDF	Tagus River
Spain			
E1	Almaraz	NPS	Tagus
E2	José Cabrera	NPS	Tagus
E3	Trillo	NPS	Tagus
E4	Juzbado	NFFEP	River Tormes - Duero
Sweden			
S1	Barsebäck	NPS	Öresund
S2	Ringhals 1-4	NPS	Kattegat
Switzerland			
CH1	Beznau	NPS	Aare
CH2	Gösgen	NPS	Aare
CH3	Leibstadt	NPS	Rhine
CH4	Mühleberg	NPS	Aare
CH5	Paul Scherrer Institute	RDF	Aare
CH6	ZWILAG Würenlingen	DMLRW	Aare
United Kingdom			
GB1	Berkeley	DMLRW	Severn Estuary
GB2	Bradwell	DMLRW	North Sea
GB3	Calder Hall	DMLRW	Irish Sea
GB4	Chapelcross	DMLRW	Solway Firth
GB5	Dungeness A/Dungeness B	NPS	English Channel
GB6	Hartlepool	NPS	North Sea
GB7	Heysham 1 / Heysham 2	NPS	Morecambe Bay
GB8	Hinkley Point A	DMLRW	Severn Estuary
GB8	Hinkley Point B	NPS	Severn Estuary
GB9	Hunterston A	DMLRW	Firth of Clyde
GB9	Hunterston B	NPS	Firth of Clyde
GB10	Oldbury	NPS	Severn Estuary

8 D21, the installation in Karlstein, was shut down in 1994. There is no radioactive waste water and therefore no discharges since 1995.

Country / Code	Name installation	Type	Discharging into
GB11	Sizewell A/Sizewell B	NPS	North Sea
GB12	Torness	NPS	North Sea
GB13	Trawsfynydd	DMLRW	Trawsfynydd lake
GB14	Wylfa	NPS	Irish Sea
GB15	Sellafield	NFRP	Irish Sea
GB16	Capenhurst	NFFEP	Irish Sea via Rivacre Brook and Mersey Estuary
GB17	Springfields	NFFEP	Irish Sea via River Ribble
GB18	Dounreay	DMLRW	Pentland Firth
GB19	Harwell	DMLRW	River Thames
GB20	Winfrith	DMLRW	Weymouth Bay (English Channel)

NPS: Nuclear Power Stations
RDF: Research and Development Facilities
NFRP: Nuclear Fuel Reprocessing Plants
NFFEP: Nuclear Fuel Fabrication and Enrichment Plants
DMLRW: Decommissiong and Management of Legacy Radioactive Wastes

Table 2 Nuclear Power Stations

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Installed Capa-city MW (e) 2005	Net Electrical Output MW (e) 2005	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2005 (TBq)															
								Specific radionuclides													
						Tritium	other (2) (3) radio-nuclides	gross (2) a-activity	gross (2) b-activity (ex.Tritium)	Co 58	Co 60	Zn 65	Sr 90	Zr/Nb 95	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144	S 35
	Belgium																				
B1	Doel	Schelde	4 PWR	393/433	349,1	3,99E+1	(4,5)	0,00E+0	4,52E-3	0,00E+0	3,09E-4	0,00E+0	3,70E-6	6,10E-6	0,00E+0	2,76E-4	2,16E-3	3,67E-5	5,81E-4	0,00E+0	
				1006/985	399,8									2,98E-5							
					907,7																
					841,8																
B2	Tihange	Meuse	3 PWR	962/1008	764,5	4,60E+1	(4,5)	2,11E-9	1,90E-2	8,40E-3	5,22E-3	0,00E+0	0,00E+0	4,92E-5	1,25E-4	7,16E-4	8,43E-4	7,89E-4	1,27E-3	9,00E-6	
				1015	899,5									2,13E-4							
					993,9																
	France (6)				**38597 Mw (e)**																
F1	Belleville-sur-Loire	Loire	2 PWR	2600		6,00E+1	2,51E-2														
						5,96E+1			2,81E-4	2,90E-5	6,64E-5					1,83E-5	5,33E-5	1,92E-5	2,47E-5		
F2	Cattenom	Mosel	4 PWR	5200		1,40E+2	5,02E-2														
						8,33E+1			7,40E-4	1,05E-4	3,00E-4					2,63E-5	4,82E-5	2,68E-5	4,62E-5		
F3	Chinon	Loire	4 PWR	3600		8,00E+1	6,06E-2														
						4,01E+1			4,48E-4	3,10E-5	7,53E-5					2,29E-5	1,57E-4	1,56E-5	1,97E-5		
F4	Chooz (7)	Meuse	2 PWR	2900		8,00E+1	2,22E-1														
						2,77E+1			6,78E-4	1,41E-4	1,10E-4					2,79E-4	4,92E-5	1,57E-5	1,90E-5		
F5	Civaux	Vienne	2 PWR	2900		8,00E+1	2,22E-1														
						4,27E+1			2,79E-4	2,72E-5	6,98E-5					7,40E-5	3,30E-5	1,11E-5	1,29E-5		
F6	Dampierre-en-Burly	Loire	4 PWR	3600		1,10E+2	1,48E+0														
						3,97E+1			5,82E-4	1,44E-4	8,81E-5					6,37E-5	6,12E-5	5,22E-5	9,58E-5		
F7	Fessenhein	Rhine	2 PWR	1800		7,50E+1	9,25E-1														
						2,02E+1			5,11E-4	1,53E-4	3,59E-5					1,72E-4	4,50E-5	7,23E-6	1,64E-5		
F8	Flamanville	North Sea (Channel)	2 PWR	2600		6,00E+1	2,51E-2														
						5,61E+1			8,05E-4	2,54E-4	2,97E-4					5,24E-5	7,38E-5	1,64E-5	2,24E-5		
F10	Golfech (8)	Garonne	2 PWR	2600		8,00E+1	1,10E+0														
						4,91E+1			3,21E-4	5,55E-5	6,90E-5					4,83E-5	4,40E-5	1,82E-5	2,06E-5		
F11	Gravelines	North Sea	6 PWR	5400		1,20E+2	9,09E-2														
						5,33E+1			2,09E-3	2,98E-4	9,15E-4					2,42E-4	1,80E-4	6,28E-5	9,50E-5		
F12	Le Blayais	Gironde Estuary	4 PWR	3600		8,00E+1	6,06E-2														
						4,59E+1			8,58E-4	1,40E-4	1,68E-4					3,25E-4	4,43E-5	1,67E-5	3,01E-5		
F14	Nogent-sur-Seine	Seine	2 PWR	2600		8,00E+1	1,10E+0														
						5,41E+1			5,13E-4	1,74E-4	1,38E-4					2,87E-5	3,93E-5	2,35E-5	3,75E-5		
F15	Paluel	North Sea (Channel)	4 PWR	5200		1,20E+2	5,02E-2														
						1,15E+2			1,56E-3	3,09E-4	6,39E-4					1,79E-4	1,16E-4	4,48E-5	5,91E-5		
F16	Penly	North Sea (Channel)	2 PWR	2600		8,00E+1	1,10E+0														
						5,34E+1			9,44E-4	1,63E-4	4,55E-4					3,23E-5	5,90E-5	3,71E-5	7,86E-5		
F18	Saint Laure des Eaux (9)	Loire	2 PWR	1800		4,50E+1	0,0303														
						1,92E+1			2,75E-4	6,82E-5	8,44E-5					3,47E-5	2,30E-5	9,00E-6	1,72E-5		

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Installed Capa-city MW (e) 2005	Net Electrical Output MW (e) 2005	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2005 (TBq)															
								Specific radionuclides													
						Tritium	other (2) (3) radio-nuclides	gross (2) a-activity	gross (2) b-activity (ex.Tritium)	Co 58	Co 60	Zn 65	Sr 90	Zr/Nb 95	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144	S 35
	Federal Republic of Germany																				
D1	Biblis A	Rhine	1 PWR	1225		3,00E+1	1,10E-1														
						1,23E+1				4,61E-6	4,28E-5					8,85E-7	1,62E-5		2,45E-6		
D1	Biblis B	Rhine	1 PWR	1300		3,00E+1	1,10E-1														
						1,51E+1				8,44E-6	1,52E-5					1,42E-7	3,13E-5	2,36E-7	7,09E-6		
D2	Brokdorf	Elbe	1 PWR	1440		3,50E+1	5,50E-2														
						1,75E+1													7,64E-8		
D3	Brunsbüttel	Elbe	1 BWR	806		3,70E+1	1,90E-1														
						2,64E-1				6,41E-7	1,16E-4	5,56E-5	1,89E-7	8,69E-8			1,06E-7	7,03E-8	2,45E-5		
D4	Grafenrhein	Main	1 PWR	1345		4,10E+1	5,50E-2														
						2,27E+1				4,40E-7	1,93E-5			1,09E-7					1,82E-6		
D5	Grohnde/	Weser	1 PWR	1430		4,80E+1	5,50E-2														
	Emmerthal					2,32E+1					1,34E-6								5,35E-8	3,66E-7	
D7	Kahl	Main	1 BWR	16	(10)	1,50E-1	4,40E-2														
						5,50E-6					4,50E-7								2,29E-7		
D8	Krümmel/	Elbe	1 BWR	1316		1,90E+1	5,00E-2														
	Geesthacht					5,51E-1				6,50E-7	1,22E-5	2,06E-6					2,40E-6				
D9	Lingen/	Ems	1 PWR	1363		3,50E+1	3,70E-2														
	Emsland					1,60E+1															
D9	Lingen	Ems	1 BWR	268	(11)	2,50E-2	2,50E-5														
						2,50E-6		6,63E-9			8,41E-8								1,38E-7		
D10	Mülheim-	Rhine	1 PWR	1302	(10)	5,00E+1	6,00E-2														
	Kärlich					2,07E-3					1,89E-6										
D11	Neckar-	Neckar	1 PWR	1365		1,90E+1	6,00E-2														
	westheim 1					1,11E+1															
D11	Neckar-	Neckar	1 PWR	357		7,00E+1	1,90E-1														
	westheim 2					2,00E+1															
D12	Obrigheim	Neckar	1 PWR	357		1,90E+1	1,90E-1														
						1,22E+0				5,12E-6	4,53E-6					4,53E-6	4,56E-7	3,29E-8	3,96E-6		
D13	Philippsburg	Rhine	1 BWR	926		1,90E+1	1,50E-1														
	KKP1					5,06E-1				5,87E-6	4,34E-5	6,54E-5		5,70E-8		5,80E-7		2,43E-6	1,03E-5	6,80E-7	
D13	Philippsburg	Rhine	1 PWR	1424		4,80E+1	1,50E-1														
	KKP2					1,61E+1				4,11E-6	1,99E-5	3,10E-7	1,40E-7	8,40E-8		2,88E-6	5,80E-7	7,42E-6	6,09E-5		
D14	Rheinsberg	Havel	1 PWR	70	(12)	2,00E+0	2,00E-3														
						5,47E-8					4,84E-7		1,89E-7						8,78E-7		
D15	Stade	Elbe	1 PWR	672		4,80E+1	1,90E-1														
						1,49E+1		2,44E-7		9,01E-8	4,77E-4		2,09E-8		1,34E-6	4,36E-6	1,77E-4		2,69E-5		
D16	Rodenkirch	Weser	1 PWR	1350		3,50E+1	7,40E-2														
	Unterweser					1,32E+1				1,52E-6	3,62E-5								1,85E-6		
D17	Würgassen	Weser	1 BWR	640	(13)	1,00E+1	6,00E-2														
	/Beverungen					2,24E-2					8,71E-6		2,01E-7						4,51E-6		
	The Netherlands																				
NL1	Borssele	Scheldt	1 PWR	485	402	3,00E+1	0,2	2,00E-4													
		Estuary				5,68E+0		<MDA (14	1,60E-4	2,37E-6	6,63E-5	<MDA	<MDA	3,65E-6	5,30E-7	3,06E-6	1,82E-7	3,09E-6	9,44E-6	1,10E-6	
NL2	Doodewaar	Waal	1 BWR	58	(15) (16)	2,00E+0	0,1	5,00E-5													

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Installed Capa-city MW (e) 2005	Net Electrical Output MW (e) 2005	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2005 (TBq)															
						Tritium	other (2) (3) radio-nuclides	Specific radionuclides gross (2) a-activity	gross (2) b-activity (ex.Tritium)	Co 58	Co 60	Zn 65	Sr 90	Zr/Nb 95	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144	S 35
	Spain																				
E1	Almaraz	Tagus	2 PWR	(19)		(17)	(17,18)														
				1957	1 800,5	1,69E+1	4,51E-3			7,06E-4	1,26E-3	3,25E-6	3,66E-5	3,04E-4		6,32E-4	1,93E-4	1,39E-5	2,83E-4		
E2	José	Tagus	1 PWR	(20)		(17)	(17,18)														
	Cabrera			150,05	124,97	3,12E+0	1,36E-4				1,95E-6							3,81E-7	7,75E-5		
E3	Trillo	Tagus	1 PWR			(17)	(17,18)														
				1 066	922,45	1,22E+1	3,93E-4			1,70E-5	1,42E-4			1,13E-5		1,87E-5	7,07E-5	7,67E-6	1,03E-4		
	Sweden																				
S1	Barsebäck	Öresund	1 BWR	600	217	(22)	(23)														
	(21)					3,50E-1		4,29E-9	3,01E-3	2,97E-4	1,93E-3	1,36E-4	1,42E-6	5,26E-6	ND	4,40E-6	1,81E-4	7,08E-6	5,41E-5	ND	
S2	Ringhals 1-	Kattegat	BWR	830	692	(22)	(23,24)														
						8,70E-1		7,80E-7	7,07E-3	1,20E-3	2,80E-3	1,60E-5	9,00E-6	1,77E-4	ND	1,50E-4	8,80E-5	3,20E-5	2,40E-4	ND	
			PWR	875	660	(22)	(23,25)														
						9,00E+0		1,65E-7	7,39E-4	1,40E-4	8,40E-5	5,50E-7	1,20E-7	1,94E-5	ND	7,00E-5	4,30E-5	4,60E-5	1,20E-4	ND	
			PWR	915	820	(22)	(23,26)														
						1,30E+1		4,76E-7	2,34E-3	1,10E-3	2,70E-4	5,70E-6	ND	1,85E-4	ND	1,30E-4	1,60E-4	2,90E-6	1,20E-5	ND	
			PWR	915	814	(22)	(23,27)														
						9,80E+0		1,86E-8	3,64E-3	2,80E-3	1,30E-4	1,30E-6	2,10E-8	2,60E-4	ND	7,40E-6	1,10E-6	ND	1,30E-6	ND	
	Switzerland																				
CH1	Beznau	Aare	2 PWR	380/380	353/320	7,00E+1	4,00E-1														
						1,10E+1	8,70E-3	2,20E-7		7,60E-3	4,40E-4	2,60E-7	7,90E-6	3,80E-6		1,30E-5	9,90E-5	3,00E-6	1,50E-4		
CH2	Gösgen	Aare	1 PWR	1015	866	7,00E+1	2,00E-1														
						1,30E+1	2,10E-6	1,30E-7		5,80E-7	1,10E-6			9,40E-8							
CH3	Leibstadt	Rhine	1 BWR	1200	655	2,00E+1	4,00E-1														
						1,20E+0	1,30E-4	2,80E-7		2,30E-6	7,90E-5							1,00E-5	1,40E-5		
CH4	Mühleberg	Aare	1 BWR	372	326	2,00E+1	4,00E-1														
						2,20E-1	2,60E-2	2,00E-7		2,20E-3	1,20E-2	9,00E-4	5,20E-6				2,70E-5	9,90E-6	2,40E-3		
	United Kingdom																				
GB5	Dungeness A	English	2 GCR	440		8,00E+0	8,00E-1												1,10E+0		
	(28)	Channel				1,21E+0	8,29E-2												1,19E-1		
GB5	Dungeness B	English	2 AGR	1110		6,50E+2	2,50E-1				3,00E-2										2,00E+0
	(29)	Channel				2,73E+2	2,94E-2				3,39E-3										3,00E-1
GB6	Hartlepool (30)	North Sea	2 AGR	1210		1,20E+3	3,00E-1				3,00E-2										3,00E+0
						2,42E+2	3,65E-3				1,01E-3										2,62E-1
GB7	Heysham 1	Morecambe	2 AGR	1150		1,20E+3	3,00E-1				3,00E-2										2,80E+0
	(31)	Bay				2,88E+2	1,46E-2				1,94E-4										1,94E-1
GB7	Heysham 2 (32)	Morecambe	2 AGR	1250		1,20E+3	3,00E-1				3,00E-2										2,30E+0
		Bay				3,26E+2	1,42E-2				1,21E-4										1,29E-1
GB8	Hinkley Point B	Severn	2 AGR	1220		6,20E+2	2,35E-1				3,30E-2										5,00E+0
	(33)	Estuary				3,58E+2	1,71E-2				1,57E-4										6,67E-1
GB9	Hunterston B	Firth of	2 AGR	1150		8,00E+2	(34)	1,00E-3	4,50E-1		3,00E-2										1,00E+1
		Clyde				3,95E+2		1,13E-4	1,01E-2		8,60E-4										6,10E-1
GB10	Oldbury (28)	Severn	2 GCR	434		1,00E+0	7,00E-1												7,00E-1		
		Estuary				3,17E-1	1,81E-1												4,20E-1		
GB11	Sizewell A (28)	North Sea	2 GCR	420		1,10E+1	7,00E-1												1,00E+0		
						2,60E-1	4,13E-1												6,51E-1		

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Installed Capa-city MW (e) 2005	Net Electrical Output MW (e) 2005	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2005 (TBq)															
								Specific radionuclides													
						Tritium	other (2) (3) radio-nuclides	gross (2) a-activity	gross (2) b-activity (ex.Tritium)	Co 58	Co 60	Zn 65	Sr 90	Zr/Nb 95	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144	S 35
GB11	Sizewell B	North Sea	1 PWR	1175		8,00E+1	2,00E-1														
						3,09E+1	2,84E-2														
GB12	Torness	North Sea	2 AGR	1264		8,00E+2	(34)	1,00E-3	4,50E-1		3,00E-2										1,00E+1
						3,81E+2		1,92E-5	2,90E-3		1,76E-4										3,13E-2
GB14	Wylfa (28)	Irish Sea	2 GCR	950		1,50E+1	1,10E-1														
						8,52E+0	2,77E-2														

Table 3 Nuclear Fuel Reprocessing Plants

Location (Map Ref.)	La Hague (F 13)			Sellafield (GB 15)	
Discharges to	English Channel			Irish Sea	
Type of Fuel Reprocessed Capacity (t/y)	PWR + BWR 1700 t/y			Magnox, AGR, LWR 1750 te/yr Magnox 1200 te/yr U oxide	
Radionuclide	**Discharge Limit in TBq per annum (1)**	**TBq released per annum**	**Normed releases in TBq per GWye (39,2 GWye in 2005)**	**Discharge Limit in TBq per annum (2, 3)**	**TBq released in 2005 (3)**
Tritium	1,85E+4	1,35E+4		2,00E+4	1,57E+3
Total-a	1,70E-1	2,15E-2	4,43E-4	1,00E+0	2,48E-1
Total-b		1,15E+1	3,34E-1	2,20E+2	4,29E+1
C 14	4,20E+1	8,27E+0		2,10E+1	5,26E+0
S 35					
Mn 54		6,55E-3			
Fe 55					
Co 57		2,16E-4		7,69E-5	
Co 58		4,04E-4			
Co 60	1,50E+0	2,27E-1		3,60E+0	6,63E-1
Ni 63		2,66E-2			
Zn 65		3,20E-4			
Sr 89		ND			
Sr 90	1,20E+1	4,97E-1		4,80E+1	1,27E+1
(Sr 90 + Cs 137)					
(Zr + Nb 95)		ND		3,80E+0	1,62E-1
Tc 99		6,01E-2		2,00E+1	6,70E+0
Ru 103		ND			
Ru 106	1,50E+1	5,84E+0		6,30E+1	1,85E+0
(Ru + Rh) 106		1,17E+1			
Ag 110m		ND			
Sb 124		ND			
Sb 125		1,73E-1			
I 129		1,40E+0		2,00E+0	2,98E-1
Cs 134	2,00E+0	6,11E-2		1,60E+0	1,64E-1
Cs 137	8,00E+0	7,12E-1		3,40E+1	5,86E+0
Ce 144		7,70E-4		4,00E+0	5,42E-1
(Ce + Pr) 144		1,54E-3			
Pm 147					
Eu 152					
Eu 154		8,65E-4			
Eu 155		2,75E-4			
Np 237		1,23E-4		1,00E+0	5,00E-2
Pu 239+240		1,08E-3		7,00E-1	2,03E-1
Pu 241		1,09E-1		2,50E+1	5,50E+0
Am 241		2,48E-3		3,00E-1	3,37E-2
Cm 242		1,71E-5			
Cm 243+244		1,69E-3		6,90E-2	4,30E-3
Uranium (in kg)		5,34E+1		2000 kg	3,69E+2

ND: not detectable

Table 4 Nuclear Fuel Fabrication and Enrichment Plants

Map Ref.	Country/ site	Discharges to	Type of Fuel	Capacity (t/y)	Production	Activity	Discharge limit in TBq per annum	TBq released in 2005
	Federal Republic of Germany							
D9	Lingen	Ems - via municipal sewer system	LWR	400		Uranium	350g uranium	not detectable
D19	Gronau	Vechte, IJsselmeer	Uranium enrichment	760		total - α	7,40E-7	2,70E-9
D20	Hanau	Main - via municipal sewer system	PWR, MOX	1350		total - α	1,50E-2	7,60E-6
	Netherlands							
NL3	Almelo	URENCO Nederland B.V. - Municipal sewer system	Uranium enrichment	2800	2352	total - α	2,00E-5	3,10E-6
						total - β (β- & γ- emitting rn)	2,00E-4	2,50E-6
	Spain							
E4	Juzbado	River Tormes - Duero	PWR, BWR	500		total - α	1,20E-2	2,88E-5
	United Kingdom							
GB16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment	NI		Uranium - α	2,00E-2	2,00E-4
						Uranium daughters	2,00E-2	4,00E-4
						other - α	3,00E-3	1,20E-5
						Tc 99	1,00E-1	1,70E-4
						Tritium	7,80E+1	3,10E-2
GB17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication	10000 te/yr as UOC		total - α	5,50E-1	2,50E-1
						total - β	1,40E+2	1,03E+2
						Tc 99	6,00E-1	6,30E-2
						Th 230	4,00E-1	8,50E-2
						Th 232	1,50E-2	3,30E-4
						Uranium α	1,00E-1	3,60E-2
						Np 237	4,00E-2	1,78E-3

Table 5 Research and Development Facilities

Map Ref.	Country/ site	Discharges to	Reactors Number & Type	Installed Capacity	Radionuclides	Discharge limit in TBq per annum	TBq released per annum in 2005
	Belgium			(1)			
B3	**Mol**	River Mol-Neet	2	129MW (th)	weighted activity	1,99E+0	6,01E-2
	Denmark						
DK1	Risø	Kattegat through Roskilde Fjord	No reactors		Tritium	(2)(3)(4)	1,64E-1
					Gross beta	(2)(3)(4)	1,18E-4
	France						
F9	Fontenay-aux-Roses	Seine	Centre de recherches du Commissariat à l'énergie atomique		α		1,71E-6
					other radionuclides		6,80E-7
					Tritium		6,30E-5
F17	Saclay	Etang de Saclay	Centre de recherches du Commissariat à l'énergie atomique		α		<9,42E-5
					other radionuclides		8,31E-4
					Tritium		3,27E-2
	Germany						
D8	Geesthacht	Elbe	1	5 MW	Tritium		2,90E-5
					Total β		1,30E-4
D18	Karlsruhe	Rhine	No reactors	None	Tritium		6,80E+0
					Total β		3,10E-5
D22	HMI Berlin	Havel	1	10 MW	Tritium		5,90E-4
					Total β		2,30E-7
D23	Jülich	Rur	1	23 MW	Tritium		6,30E-1
					Total β		1,50E-4
D24	Rossendorf	Elbe	No reactors	None	Tritium		4,00E-2
					Total β		7,10E-6
	Netherlands						
NL4	Delft (5)(6)(7)	Sewage system	1	6 MW (th)	α - emitting radionuclides		<3.3E-7
					β - emitting radionuclides including tritium		1,30E-5
					γ - emitting radionuclides		
					total	20 gew Re,ing (5+8)	
NL5	Petten (9)(10)(11)	North Sea	1 HFR for material testing				
				60 MW (th)	Tritium		2,61E-1
			1 LFR		α - emitting radionuclides		3,71E-6
				30 MW (th)	β/γ - emitting radionuclides		7,55E-2
					total	2000 gew Re,ing (8+9)	
	Norway (12)						
N1	Halden (13)	River Tista (Skagerrak)	1 BWR D2O as moderator		Tritium		5,30E-1
					Total α		0,00E+0
					Total β (14)		3,90E-4
					Ag-110m		9,40E-7
					Cr-51	2,50E+0	1,80E-4
					Mn-54	2,35E-2	2,50E-6
					Mn-56	1,55E-1	n.r.
					Co-58	1,97E-2	4,10E-5

Map Ref.	Country/ site	Discharges to	Reactors Number & Type	Installed Capacity	Radionuclides	Discharge limit in TBq per annum	TBq released per annum in 2005
					Co-60	5,66E-3	9,90E-5
					Sr-90	1,29E-2	4,90E-6
					Zr-95	5,90E-3	5,30E-6
					Nb-95	1,29E-2	1,20E-5
					Sb-125	1,58E-1	3,70E-8
					Cd-109		n.r.
					I-131	6,80E-1	4,20E-7
					Cs-134	5,30E-2	1,80E-5
					Cs-137	8,33E-2	1,30E-4
					Ce-141	3,09E-2	6,12E-7
					Ce-144	3,55E-2	8,80E-6
N2	Kjeller (13)	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled Research Reactor		Tritium		4,14E-1
					Total-α		1,87E-7
					Total-β		1,12E-4
					Co 58	3,00E-3	<1.00E-7
					Co 60	1,09E-3	6,70E-6
					Zn 65	1,75E-3	8,40E-6
					Sr 90	4,81E-3	2,70E-7
					Zr/Nb 95	7,20E-4	3,00E-7
					Ru 103	2,04E-3	<3.00E-7
					Ru 106	2,00E-3	<2.20E-6
					Ru/Rh 106		n.r.
					Ag 110m	1,14E-2	1,20E-6
					Sb 125	3,00E-2	<0.70E-6
					I 125	2,52E-2	5,00E-5
					I 131	1,29E-2	3,90E-5
					Cs 134	1,30E-4	8,00E-8
					Cs 137	2,72E-4	5,10E-7
					Ce 144	5,24E-3	5,40E-8
					Pu 238	1,96E-2	7,00E-9
					Pu 239/240	2,05E-2	1,50E-7
					Am 241	2,45E-3	3,00E-8
					Pu 241		n.r.
	Portugal						
P1	Campus de Sacavém	Residual Water Treatment Municipal Plant	1 Research Swimming Pool Reactor	1 MW		3,05E-4	
	Switzerland						
CH5	Paul Scherrer Institute	Aare	1 research reactor	zero power	Tritium	(15)	1,10E-2
					Total-β		
					other radionuclides	(15)	3,60E-5
					β– and γ– emitting radionuclides		
					Be-7		2,30E-8
					Na-22		5,30E-6
					Mn-54		2,80E-6
					Co-57		1,20E-8
					Co-58		1,40E-8
					Co-60		1,50E-6
					Sr-85		9,30E-8

Map Ref.	Country/ site	Discharges to	Reactors Number & Type	Installed Capacity	Radionuclides	Discharge limit in TBq per annum	TBq released per annum in 2005
					Sr/Y-90		1,90E-6
					I-125		3,10E-6
					I-131		1,50E-6
					Cs-134		2,50E-6
					Cs-137		1,50E-5
					Eu-152		2,10E-8
					Lu-177		1,30E-6
					α - emitting radionuclides		
					Pu-238/Am-241		2,20E-7
					Pu-239/240		5,60E-7

Table 6 Discharges from decommissioning and treatment/recovery of old radioactive waste in 2005

Map Ref.	Country Site	Discharges to	Reactors Number and Type	Discharge limits (upper row value) and releases (lower row value) of radioactive substances (1) in 2005 (TBq)																
						Specific radionuclides														
				Tritium	other (2) (3) radio-nuclides	gross (2) a-activity	gross (2) b-activity (ex.Tritium)	Co 58	Co 60	Zn 65	Sr 90	Na22	Ru 106	Ag 110m	Sb 125	Cs 134	Cs 137	Ce 144	S 35	Pu-241
	Switzerland																			
CH6	ZWILAG*	Aare			2,00E-1															
				1,20E-2	1,70E-4	1,50E-8			1,20E-5	1,70E-7	9,90E-7			9,00E-8	4,00E-5		1,20E-4			
	United Kingdom																			
GB1	Berkeley (1)	Severn	2 GCR	2,00E+0	4,00E-1												2,00E-1			
		Estuary		5,90E-4	4,73E-3												6,71E-3			
GB2	Bradwell (1)	North Sea	2 GCR	7,00E+0	7,00E-1												7,00E-1			
				3,17E-1	3,51E-1												2,88E-1			
GB3	Calder Hall (2)	Irish Sea	4 GCR	Reported with Sellafield's discharges																
GB4	Chapelcross	Solway Firth	4 GCR	5,50E+0	(3)	1,00E-1	2,50E+1													
				3,33E-2		1,04E-5	4,90E-3													
GB8	Hinkley Point A	Severn	2 GCR	1,80E+0	7,00E-1												1,00E+0			
	(1)	Estuary		3,79E-1	1,56E-1												1,93E-1			
GB9	Hunterston A	Firth of	2 CGR	7,00E-1	(4)	4,00E-2	6,00E-1													1,00E+0
		Clyde		4,78E-4		1,30E-4	4,72E-2													1,50E-4
GB13	Trawsfynydd	Trawsfynydd	2 GCR	5,00E-1	1,70E-1						5,00E-2						3,00E-2			
	(1)	lake		1,64E-2	3,32E-3						7,60E-4						1,22E-3			
GB18	Dounreay (5	Pentland Firth	No reactors	(5)																
				9,94E-2		7,39E-4	5,91E-3				1,02E-1	1,27E-1					2,09E-2			
GB19	Harwell	River Thames	No reactors																	
				4,08E-3		1,90E-5	2,35E-4		4,38E-6								4,38E-5			
GB20	Winfrith	Weymouth Bay	No reactors																	
		(English Channel)		8,54E+0	1,11E-2	2,76E-4			5,06E-4	2,94E-4										

*A central interim storage facility including a waste treatment plant (ZWILAG) was put in operation in Switzerland. First year of reporting of discharges from this facility.

4. Footnotes to tables 2 to 5

Table 2

(1) Discharge limits are given in row above the actual releases.

(2) The value indicated corresponds to the sum of individually assessed nuclides.

(3) France informs that the second column corresponds to the sum of the following radionuclides: 54Mn, 58Co, 60Co, 110mAg, 123mTe, 124Sb, 125Sb, 131I, 134Cs, 137Cs, 51Cr. It does not take into account pure beta-emitters (C14, Ni63).

(4) Value of "other radionuclides" (= total Beta-Gamma) reported as mentioned in the 'instructions for the reporting format for liquid discharges of radioactive substances from nuclear installations' (point 8)

(5) For Belgium, the nuclides included are:

ß-Activity for Tihange: Sr-89, Sr-90, ß-Activity for Doel: Sr-89, Sr-90, Other radionuclides for Tihange: Na-24, Cr-51, Mn54, Co-57, Co-58, Co-60, Fe-59, Zn-65, Zr-95, Nb-95, Mo-99, Tc99m, Ru-103, Ru-106, Ag-110m, Sb-122, Te-123m, Sb-124, Sb-125, I-131, Cs-134, Cs-136, Cs-137, Ba-140, La-140, Ce-141, Ce-144, Other radionuclides for Doel: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, Zn-65, Zr-95, Nb-95, Ru-103, Ru-106, Ag-110m, Te-123m, Sb-124, Sb-125, I-131, Cs-134, Cs-137, Ba-140, La-140, Ce-141, Ce-144.

(6) France explains that there is no simple relationship between the production of electricity and discharges of radioactive effluent other than tritium. This is because the amounts of effluent discharged depend on many factors: the condition of fuel cladding (first barrier), the processing carried out in the various existing plants, the operational mode of the reactor (load-following or providing basic power) and, above all, the volume of work carried out during shutdowns for refuelling.

Moreover, electricity is produced according to a programme fixed station by station at national level, and deliberate shutdowns, either during stand-by periods or for work to be carried out, are fixed by national criteria: the end of a natural cycle, arrangements for maintenance depending on the availability of teams of workers, constraints of the national grid and the demand for electricity.

It is easy to understand that a unit can operate over a calendar year and can produce a lot of power if it has been refuelled at the end of the previous year and if it is made to extend its cycle. In this case, the production of effluent will be minimised (no work is carried out). On the other hand, a unit shutdown for a long time (decennial shut-down, typically) will show an increase in the production of effluent and a decrease in the power supplied. During the next year, these two scenarios may be reversed. There is therefore good reason not to attempt a comparison of one site with another over short periods (= 10 years) as regards the quantity of radioactive effluent (other than tritium) discharged for a given amount of electrical energy produced.

In order to eliminate the variability associated with specific operating conditions of each reactor, it is more appropriate for a given year to consider the total amount of electricity generated by the French facilities in the OSPAR area. In 2005, their net electrical output was 38597 MW(e)a.

(7) Chooz A ceased to operate on 30.10.1992. Chooz B1 was connected to the grid on 30.8.1996.

(8) Second reactor was connected to the grid on 28.5.1993.

(9) Ceased to operate on 27.5.1992.

(10) Shut down in 1986.

(11) Shut down in 1977.

(12) Shut down in 1990.

(13) Shut down in 1994.

(14) "Total-β" values represent an assimilation of β-emitting and γ-emitting radionuclides.

(15) Dodewaard shut down 26 March 1997.

(16) KCD is in Safe Enclosure condition and does not discharge liquids. The small quantities of processed water are treated off site (COVRA).

(17) During normal operation, each facility has to comply with a discharge limit of 0,1 mSv/year effective dose to individuals of the critical group, which is distributed between liquid and gaseous effluents in accordance with the criteria established in the Offsite Dose Calculation Manual.

(18) In 2005, the detected radionuclides for Almaraz were: Na-24, Cr-51, Mn-54, Co-58, Fe-59, Co-60, Zn-65, Sr-89, Sr-90, Nb-95, Zr-95, Ag-110m, Sb-122, Te-123m, Sb-124, Sb-125, Cs-134, Cs-137. The detected radionuclides for José Cabrera were: Co-60, Cs-134, Cs-137, I-131, I-132, I-133, I-134,

I-135. The detected radionuclides for Trillo were: Cr-51, Mn-54, Co-58, Co-60, Nb-95, Zr-95, Ag-110m, Sb-122, Te-123m, Sb-124, Sb-125, Cs-134, Cs-137.

(19) New value authorised since January 2004.

(20) New value authorised since 1 March 2004.

(21) Discharges into the Øresund (HELCOM area adjacent to the OSPAR Maritime Area). Data provided for information only.

(22) Discharges from Swedish nuclear facilities are regulated on the basis of dose to critical group. The annual effective dose to individuals of the critical group shall during normal operation not exceed 0,1 mSv. The 2005 discharges to the marine environment from the Ringhals Nuclear Power Plant correspond to annual effective doses of 0,017mikrosivert.

(23) Total α-, β-, and γ-activity excluding Tritium.

(24) For Ringhals unit 1 the detected radionuclides were: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, Zn-65, As-76, Sr-89, Sr-90, Nb-95, Zr-95, Ag-108m, Ag-110m, Sn-113, Sb-122, Sb-124, Sb-125, Cs-134, Cs-137, Pu-238, Pu-239, Am-241, Cm-242, Cm-244, I-131.

(25) For Ringhals unit 2 the detected radionuclides were: Be-7, Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, As-76, Sr-90, Nb-95, Zr-95, Ag-108m, Ag-110m, Sn-113, Sb-122, Sb-124, Sb-125, I-131, Cs-137, Ce-144, Pu-238, Pu-239, Am-241, Cm-242, Cm-244.

(26) For Ringhals unit 3 the detected radionuclides were: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, Zn-65, As-76, Sr-89, Sr-90, Nb-95, Zr-95, Ag-108m, Ag-110m, Sn-113, Sb-122, Sb-124, Sb-125, Cs-134, Cs-137, Pu-238, Pu-239, Am-241, Cm-242, Cm-244, I-131.

(27) For Ringhals unit 4 the detected radionuclides were: Cr-51, Mn-54, Co-57, Co-58, Co-60, Fe-59, As-76, Sr-89, Sr-90, Nb-95, Zr-95, Ag-108m, Ag-110m, Sn-113, Sb-122, Sb-124, Sb-125, Cs-134, Cs-137, Pu-238, Pu-239, Am-241, Cm-242, Cm-244, I-131.

(28) Discharge limits were revised on 18th December 2002.

(29) Dungeness B also discharges sulphur-35 in a liquid form. The discharge limits and values for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and in 2005 were as follows: limit 2 TBq; discharge 0,305TBq.

(30) Hartlepool also discharges sulphur-35 in a liquid form. The discharge limits and values for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and in 2005 were as follows: limit 3 TBq; discharge 0,623 TBq.

(31) Heysham 1 also discharges sulphur-35 in a liquid form. The discharge limits and values for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and in 2005 were as follows: limit 2,8 TBq; discharge 0,162 TBq.

(32) Heysham 2 also discharges sulphur-35 in a liquid form. The discharge limits and values for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and in 2005 were as follows: limit 2,3 TBq; discharge 0,0849 TBq.

(33) Hinkley B also discharges sulphur-35 in a liquid form. The discharge limits and values for sulphur-35 have not been included in the ‘other radionuclides’ category in the table and are as follows: limit 5 TBq; discharge 0,475 TBq.

(34) Gross alpha, total beta and Co-60, excluding tritium. This value includes S-35, for Hunterston B the S-35 limit is 10 TBq, discharged 0,98 TBq. For Torness S-35 limit is 10 TBq discharged 0,0193 TBq.

Table 3

(1) Discharges of the Centre de Stockage de la Manche (low and intermediate level waste disposal site) are included in the La Hague discharges.

(2) The values of the liquid discharge limits for tritium and iodine-129 vary depending on the annual mass throughput of uranium in THORP (Thermal Oxide Reprocessing Plant), at Sellafield which was 613 tonnes in 2002.

(3) Discharges from Calder Hall Nuclear Power Station are included in the discharges from Sellafield.

Table 5

(1) The installed capacity is the maximum value. The reactors function in a discontinuous way, often at a fraction of their maximum.

(2) Additionally reporting required at discharges of H-3 above 2 TBq in one month.
Additionally reporting required at discharges of Gross beta above 0,3E-03 TBq in one month.

(3) Discharge limit for H-3: 1,000 TB per year.
Discharge limit for Gross beta: 0,2 TBq per year.

(4) All three Danish research reactors have been taken out of operation and the process of decommissioning has started. As a consequence the discharge limits and the reporting obligations set in the Operational limits and Conditions have been revised. The annual discharges reported are now exclusively from the Waste Management Plant.

(5) The data represent the total emissions/discharges from the Interfaculty Research Institute (IRI) complex, including the IRI-Higher Research Reactor (HOR) and different laboratories (it is not possible to make a distinction between the various sources). The discharges from the IRI-HOR are substantially lower than the values reported. At the end of 1996 the permit regarding discharges to sewage were changed into a maximum value of 20 weighted Re,ing per year.

(6) "DNL01 site Delft" refers to Research reactor of Technical University Delft.

(7) For DNL01, Delft: "Total-β" value represents all β-emitting nuclides, including tritium.

(8) Depending on the half life of the individual radionuclides. 1 weighted Re,ing corresponds with the following amounts of radioactivity expressed in ICRP-61 Annual Limit Intake (ALI) -units:

0,5	ALI	for	t ½	>	250	year		
5	ALI	for	250 year	>	t ½	>	25	year
50	ALI	for	25 year	>	t ½	>	15	days
500	ALI	for	15 days	>	t ½	>	7,5	days
5 000	ALI	for	7,5 days	>	t ½	>	5	days
50 000	ALI	for	5 days	>	t ½			

(9) The data represent the total emissions/discharges from the Petten complex. This will lead to a substantial overestimate of the discharges of the two reactors (it is not possible to distinct the discharges from each separate reactor). In all cases concentrations of α-emitters were lower than the detection limit, which is used for load calculations. The discharge limits for Petten have been changed into 2000 weighted Re,ing per year.

(10) "DNL02 site Petten" refers to Research reactor of EU-JRC

(11) For DNL02, Petten: "Total-β" value represents an assimilation of β-emitting and γ-emitting radionuclides.

(12) Some radionuclides reported to be discharged in small amounts (most have been reported as “less than” values) by IFE are not included as specific nuclides in the spreadsheet.
From IFE Kjeller, these radionuclides are: Mn-54, Cr-51, Fe-59, Ru-103, Ru-106, Sb-124
From IFE Halden, these radionuclides are: Fe-59, Ru-103, Sb-124
All these have been included in the total-beta.

(13) Annual discharge data of gaseous effluents are also available.

(14) Figure for Total-β does not include tritium.

(15) For the Paul Scherrer Institute, the release of radioactivity through the exhaust air and the wastewater systems are directly limited to 0,15 mSv/year via the source-related dose guideline.

Table 6

(1) Discharge limits were revised on 18th December 2002.

(2) Calder Hall permanently shut down in March 2003.

(3) Gross alpha and beta activity excluding tritium.

(4) Hunterston A gross alpha and beta activity excluding tritium. This value includes Pu-241 discharge limit 1 TBq, discharged 0,000206 TBq.

(5) The prototype fast reactor was shut down on 31 March 1994 and there is to be no further fuel reprocessing at Dounreay.