OSPAR COMMISSION

Protecting and conserving the North-East Atlantic and its resources

Annual report and assessment of liquid discharges from nuclear installations in 2018

Radioactive Substances Series

2020

Report on Liquid Discharges from Nuclear Installations in 2018

OSPAR Convention

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. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Convention OSPAR

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. Les Parties contractantes sont l'Allemagne, la Belgique, le Danemark, l'Espagne, 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, la Suisse et l'Union européenne.

Acknowledgement

This report has been prepared by the Expert Assessment Panel of the OSPAR Radioactive Substances Committee, comprising of Mr Michel Chartier (convenor), France, Mr Andrew Pynn, United Kingdom and Ms Inge Krol, Germany with the support of Miss Lucy Ritchie and Mr Chris Moulton of the OSPAR Secretariat.

Contents

Executive summary

This report presents the 2018 data of liquid radioactive discharges from nuclear installations and temporal trends for the period 1989 - 2018. 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, research and development facilities, and decommissioning and management of legacy radioactive wastes activities. Discharges are reported as total alpha, tritium and total beta activity (excluding tritium) in terabecquerel per year (TBq/y) for each type of nuclear installation.

The total discharges of alpha activity from all nuclear installations in 2018 were 0.19 TBq which is 16% lower than the previous year and 36% lower than in 2016. Annual alpha discharges have fluctuated in the range 0.17 – 0.3 TBq since 2007, and in 2018 were about 6.5% of the peak since 1990 (in 1993).

Discharges of total beta activity (excluding tritium) from all nuclear installations has decreased markedly since 1989 and are now only 1.8% of what they were in 1989. In 2018 total beta discharges were about 17 TBq, a significant decrease relative to the previous year (26%).

The total discharge of tritium in 2018 of about 16,000 TBq is similar to annual discharges made in recent years and about 23% lower than the peak seen in 2004. Discharges of tritium are dominated by those from the reprocessing sector (80% in 2018, with 72% of the total from Cap de la Hague) and fluctuate in accordance with spent fuel reprocessing rates.

Récapitulatif

Le présent rapport annuel comporte les données de 2018 sur les rejets radioactifs liquides provenant des installations nucléaires et les tendances temporelles pour la période de 1989 à 2018. Une évaluation a été réalisée, à partir de ces informations, portant sur les rejets provenant des centrales nucléaires, des usines de retraitement de combustible nucléaire, des usines de production de combustible nucléaire et des usines d’enrichissement, des installations de recherche et de développement ainsi que des activitès de démantèlement de gestion des déchets radioactifs hérités. Les rejets sont notifiés au titre des activités d’alpha total, de tritium et de bêta total (à l’exclusion du tritium) et exprimés en terabecquerel par an (TBq/y) pour chaque type d’installation nucléaire.

L’activité d’alpha total rejetée par toutes les installations nucléaires en 2018 était de 0,19 TBq, soit 16 % de moins que l'année précédente et 36 % de moins qu'en 2016. Les rejets alpha annuels ont fluctué entre 0,17 et 0,3 TBq depuis 2007, et en 2018, ils représentaient environ 6,5 % du pic enregistré depuis 1990 (en 1993).

L’activité de bêta total (à l’exclusion du tritium) rejetée par toutes les installations nucléaires a diminué de manière significative depuis 1989 et ne représente actuellement que 1.8 % du niveau enregistré en 1989. En 2018, les rejets totaux de bêta étaient d'environ 17 TBq, ce qui représente une baisse significative par rapport à l'année précédente (26 %).

Le rejet total de tritium en 2018, d'environ 16 000 TBq, est similaire aux rejets annuels de ces dernières années et inférieur d'environ 23 % au pic observé en 2004. Les rejets de tritium sont dominés par ceux du secteur du retraitement (80 % en 2018, dont 72 % du total pour le Cap de la Hague) et fluctuent en fonction des taux de retraitement des combustibles usés.

1. Introduction

Work to prevent and reduce pollution from ionising radiation in the North-East Atlantic was first undertaken within the framework of the former 1974 Convention for the Prevention of Marine Pollution from Land-based Sources (the "Paris Convention") and then under the 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention"), which replaces the Paris Convention and establishes the OSPAR Commission.

At the first Ministerial Meeting of the OSPAR Commission (20-24 July 1998, Sintra, Portugal), an OSPAR Strategy for Radioactive Substances was adopted 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 at the third Ministerial Meeting of the OSPAR Commission (23-24 September 2010, Bergen, Norway), where the Strategy of the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic 2010-2020 (the "North-East Strategy") was adopted.

The North-East Atlantic Environment Strategy sets out OSPAR's vision, objectives, strategic directions and action for the period up to 2020. In Part I, the new Strategy gives prominence to the overarching implementation of the ecosystem approach and the need for integration and coordination of OSPAR's work across themes and groups. In Part II, the Strategy provides its thematic strategies for Biodiversity and Ecosystems, Eutrophication, Hazardous Substances, Offshore Oil and Gas Industry and Radioactive Substances.

The Radioactive Substances thematic Strategy (Radioactive Substances Strategy) sets the objective of *preventing pollution of the OSPAR 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: (1) radiological impacts on man and biota, (2) legitimate uses of the sea, and (3) technical feasibility.

As its timeframe, the Radioactive Substances Strategy further declares that the OSPAR Commission will implement this Strategy progressively by making every endeavour, through appropriate actions and measures to ensure that by the year 2020 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, emissions and losses, are close to zero.

The Radioactive Substances Strategy provides that in accordance with the provisions of the OSPAR Convention and the findings of the Quality Status Report 2010, the OSPAR Commission will, where appropriate, develop and maintain programmes and measures to identify, prioritise, monitor and control the emissions, discharges and losses of the radioactive substances caused by human activities which reach or could reach the marine environment.

To this end, the Radioactive Substances Strategy requires the OSPAR Commission to continue the annual collection of data on discharges of radionuclides from the nuclear sector. Regular reporting is therefore required in order to review progress towards the targets of the Radioactive Substances Strategy.

1.1 Programmes and measures

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

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

- PARCOM Recommendation 88/4 on Nuclear Reprocessing Plants;
- PARCOM Recommendation 91/4 on Radioactive Discharges [3];
- PARCOM Recommendation 94/8 Concerning Environmental Impact Resulting from Discharges of Radioactive Discharges [4];
- OSPAR Decision 2000/1 on Substantial Reductions and Elimination of Discharges, Emissions and Losses of Radioactive Discharges, with Special Emphasis on Nuclear Reprocessing.

The OSPAR Fourth Periodic Evaluation of the Progress in Implementing the OSPAR Radioactive Substances Strategy, published in 2016 (OSPAR publication 2016/687), 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, collated by the Secretariat and, following examination by the Expert Assessment Panel (EAP) of the OSPAR Radioactive Substances Committee, published by the OSPAR Commission in the form of annual reports. At first annual reports were published as part of the OSPAR Commission's general Annual Report, and from 1991 onwards they are published in the form of Annual OSPAR Reports on Liquid Discharges from Nuclear Installations in the OSPAR maritime area. From 1998 onwards, the annual reports also contain an assessment of liquid discharges which include a description of the trends from 1989 until the date of the latest report. 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 OSPAR Commission. With a view to harmonising the way in which data and information are being established and reported, the OSPAR Commission adopted in 1996 a set of reporting formats for the annual Collection of Data on Liquid Discharges from Nuclear Installations, which were updated in 2010 to include a guide to generate "total-α" and "total-β" discharge data. There was a further update of the set of reporting formats in 2013 (OSPAR Agreement number: 2013-10).

RSC decided at the meeting 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

Tables 1-8 of this report contain data on total-α (Table 1), tritium (Table 2), total-β (Table 3), and individual radionuclides (Tables 4-8). Figures 1-3 of this report show trends in discharges of total-α activity, tritium and total-β activity respectively.

Total-α and total-β 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-α and total-β values provide limited information about the potential harm and, as

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2 OSPAR Decision 2000/1: France and the United Kingdom 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 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: 2004-03).

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 (EC, 2003).

such, information should be based on the characteristics of individual radionuclides. Tritium is reported separately.

There is currently little consistency in the approach adopted by Contracting Parties in the assessment of total-α and total-β quantities. Consequently, for the purposes of this report total-α quantities include measurements that are strictly gross-α. The calculation of total-β varies between Contracting Parties, for example, in some cases it is the sum of individual radionuclide measurements and in other cases gross-β measurements are used.

Total-α represents the measured radioactivity of α-particle emitting radionuclides. These particles are emitted as a result of the decay of certain radionuclides, the so-called α-emitters. Typically, 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. Total-β represents the sum of the measured radioactivity of β-particle emitting radionuclides. These particles 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-β 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 β-particles. Tritium is discharged from most nuclear power plants, reprocessing plants and some research and development facilities.

2. Assessment of the liquid radioactive discharges from nuclear installations in 2018

Introduction

Tables 1 to 3 summarise liquid radioactive discharges from nuclear installations for the period 1989 – 2018 (i.e. 30 years of discharge data); data are taken from the OSPAR Annual Reports on Liquid Discharges from Nuclear Installations[5]. Reported discharges include data on operational discharges from nuclear power stations, nuclear fuel reprocessing plants, nuclear fuel fabrication and enrichment plants, and research and development facilities. Since 2006, exceptional discharges associated with the recovery of historical or legacy waste and decommissioning are reported separately for some sites. In 2014 the Contracting Parties agreed to apply the definitions for 'operational' and 'exceptional' discharges adopted at RSC 2013 and these definitions were included in the guidance to the revised reporting formats for discharges made since 2013. Such differentiation is becoming particularly important where the magnitude of discharges associated with the recovery of historical and legacy wastes and decommissioning is clearly evident. In recent years, the contribution of these 'exceptional' discharges has increased to become one of the main contributor of discharges from nuclear installations.

Table 1 gives discharges of total alpha activity, Table 2 gives tritium discharges and Table 3 gives discharges of total beta activity (excluding tritium) in terabecquerels per year (TBq/y) for each sub-sector. The tables also give the percentage contributions from each sub-sector. Figures 1 to 3 show the trends in annual discharges of total alpha, tritium and total beta (excluding tritium) for the period 1989 to 2018 (three decades trend).

Trends in total alpha discharges

Table 1 and Figure 1 show the total alpha activity discharged from 1989 to 2018. The total discharges of alpha activity from all nuclear installations in 2018 were 0.19 TBq which is 16% lower than the previous year and 36% lower than in 2016. Annual alpha discharges have fluctuated in the range 0.17 – 0.3 TBq since 2007, and in 2018 were about 6.5% of the peak since 1990 (in 1993).

Discharges from the fuel reprocessing sub-sector contributed about 51% of the overall total alpha discharges in 2018 at 0.095 TBq. Operational discharges from Sellafield contributed about 42% (0.079 TBq). The variations mainly reflect spent fuel throughput and fuel burn up.

Total alpha discharges arising from decommissioning have been recorded separately since 2006. In 2018 the 'exceptional' discharges[2] from this sub-sector were 0.084 TBq (17% higher than in the previous year), about 45% of the total from all nuclear installations. 'Exceptional' discharges is the second contributor to the total from all nuclear installations since several years, nearly at the same level as the first contributor (the fuel reprocessing sub-sector).

The discharges from the fuel fabrication and enrichment sub-sector contributed about 4% to the total alpha discharges in 2018 at 0.0078 TBq, which is 57% lower than the previous year. Most of the discharges of total alpha from this sub-sector are due to the discharges from the Springfields fuel fabrication plant in the UK.

Discharges of alpha activity from nuclear power plants and research and development facilities in 2018 were a very small fraction of the total discharge (≈1 $^{0}/_{00}$).

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[5] Discharge data have been rounded to two significant figures in this assessment report.

Trends in tritium discharges

Table 2 and Figure 2 present the discharges of tritium, a weak beta emitter with a low radiological impact. The total discharge of tritium in 2018 of about 16,000 TBq is similar to annual discharges made in recent years and about 23% lower than the peak seen in 2004. Discharges of tritium are dominated by those from the reprocessing sector (80% in 2018, with 72% of the total from Cap de la Hague) and fluctuate in accordance with spent fuel reprocessing rates.

During 2018 the discharge of tritium by nuclear power stations increased by about 2% over the previous year and contributed a similar fraction of about 20% of the total tritium discharges from the nuclear sector; this fraction remains of the same order of magnitude from 1995. The UK's Advanced Gas-cooled Reactors contributed about 64% (2,020 TBq) of the total from power stations. The Pressurised Water Reactors in France contributed about 26% (860 TBq) of the total from power stations in 2018.

Tritium discharges arising from exceptional discharges have been recorded separately since 2006, and continue to be a relatively small and variable contribution depending upon decommissioning and legacy waste management operations. Discharges in 2018 were 23 TBq (similar to the previous year) which was about 0.1% of the total across all sub-sectors.

Discharges from other sub-sectors were relatively very small.

Trends in total beta discharges

Table 3 and Figure 3 show that the discharges of total beta activity (excluding tritium) from all nuclear installations has decreased markedly since 1989 and are now only 1.8% of what they were in 1989. In 2018 total beta discharges were about 17 TBq, a significant decrease relative to the previous year (26%).

Historically, total beta discharges have been dominated by discharges from the reprocessing plants at Sellafield and the nuclear fuel fabrication plant at Springfields to a lesser extent. In 2018, the contribution of the reprocessing sub-sector (44%) is much lower than the peak contribution of this sub-sector (89% in 2007); the reprocessing plants at Sellafield and Cap de la Hague contributed 30% and 14% respectively to operational discharges of total beta activity. Between the mid-1990s and 2002 total beta discharges from Sellafield were mainly attributable to the radionuclide technetium-99. The contribution from technetium-99 to the total beta discharge at Sellafield has reduced very substantially since 2001. In 2018 the discharge of technetium-99 from Sellafield was 0.73 TBq, which is 35% lower than the previous year.

Discharges from decommissioning, and the management of historical or legacy waste, had steadily increased until 2016 primarily due to more nuclear installations entering the decommissioning phase, and still increased in 2018. The contribution of exceptional discharges reached 33% of all installations in 2018; it is now the second largest contributor.

Discharges from power stations over recent years have fluctuated but are typically one half of the reprocessing sub-sector. In 2018 power stations were the third largest contributor (21.5%) to total discharges after reprocessing and decommissioning.

Discharges from the R&D sub-sector remained as the smallest contributor to total discharges.

Table 1. Total alpha discharges 1989-2018

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
All Nuclear Installations (TBq)	3,1E+00	2,4E+00	2,4E+00	1,8E+00	2,9E+00	1,4E+00	6,8E-01	5,7E-01	3,8E-01	4,3E-01	4,1E-01	3,3E-01	4,1E-01	6,1E-01	6,2E-01
Reprocessing Plants (TBq)	2,7E+00	2,2E+00	2,3E+00	1,7E+00	2,7E+00	1,1E+00	4,7E-01	3,2E-01	2,3E-01	2,2E-01	1,7E-01	1,6E-01	2,5E-01	3,9E-01	4,3E-01
% of all installations	86	91	93	93	94	81	69	56	61	51	41	48	60	63	70
Nuclear Power Plants (TBq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% of all installations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nuclear Fuel Fabrication (TBq)	4,1E-01	2,1E-01	1,5E-01	1,0E-01	8,0E-02	1,6E-01	1,2E-01	1,2E-01	1,2E-01	2,0E-01	2,4E-01	1,7E-01	1,6E-01	2,2E-01	1,8E-01
% of all installations	13	8,6	6,2	5,4	2,8	12	18	21	32	46	58	52	40	36	30
Research and Development Facilities (TBq)	3,0E-02	2,0E-02	3,0E-02	3,0E-02	1,0E-01	1,0E-01	9,0E-02	1,3E-01	2,7E-02	1,3E-02	3,0E-03	1,8E-03	1,6E-03	2,1E-03	4,4E-03
% of all installations	1	0,82	1,2	1,6	3,5	7,4	13	23	7,2	3,0	0,73	0,55	0,38	0,34	0,71
Decommissioning (TBq)															
% of all installations															

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
All Nuclear Installations (TBq)	5,4E-01	5,2E-01	3,4E-01	1,9E-01	1,7E-01	1,8E-01	1,8E-01	1,7E-01	1,9E-01	2,0E-01	2,2E-01	2,3E-01	2,9E-01	2,2E-01	1,9E-01
Reprocessing Plants (TBq)	3,1E-01	2,7E-01	2,3E-01	1,5E-01	1,4E-01	1,5E-01	1,6E-01	1,4E-01	1,6E-01	1,5E-01	1,8E-01	1,9E-01	2,5E-01	1,3E-01	9,5E-02
% of all installations	57	52	68	77	83	88	86	85	86	74	83	82	85	59	51
Nuclear Power Plants (TBq)	-	-	-	-	-	-	-	-	3,4E-04	1,3E-05	3,9E-05	4,1E-05	3,4E-05	3,12E-05	3,3E-05
% of all installations	-	-	-	-	-	-	-	-	0,18	0,0069	0,018	0,018	0,012	0,014	0,018
Nuclear Fuel Fabrication (TBq)	2,3E-01	2,5E-01	1,1E-01	4,4E-02	2,2E-02	1,7E-02	2,1E-02	2,2E-02	2,4E-02	1,6E-02	1,4E-02	2,3E-02	1,5E-02	1,8E-02	7,8E-03
% of all installations	43	48	32	23	13	9,8	12	13	13	8,2	6,6	9,8	5,2	8,2	4,2
Research and Development Facilities (TBq)	9,0E-04	1,0E-03	1,2E-04	1,2E-04	9,0E-05	6,2E-05	6,2E-05	7,7E-05	8,9E-05	5,7E-05	7,3E-03	1,3E-04	1,2E-04	6,56E-05	1,14E-04
% of all installations	0,17	0,2	0,035	0,063	0,052	0,035	0,034	0,047	0,048	0,029	3,3	0,1	0,0	0,0	0,1
Decommissioning (TBq)			5,8E-04	5,9E-04	6,3E-03	3,6E-03	4,5E-03	2,8E-03	2,3E-03	3,4E-02	1,6E-02	1,8E-02	3,0E-02	7,2E-02	8,4E-02
% of all installations			0,17	0,31	3,6	2,1	2,5	1,7	1,2	17	7,2	7,9	10,3	32,4	44,9

Table 2. Tritium discharges 1989-2018

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
All Nuclear Installations (TBq)	8,0E+03	7,2E+03	8,8E+03	7,7E+03	1,1E+04	1,3E+04	1,5E+04	1,7E+04	1,8E+04	1,6E+04	1,9E+04	1,7E+04	1,6E+04	1,9E+04	2,0E+04
Reprocessing Plants (TBq)	5,8E+03	5,0E+03	6,5E+03	5,0E+03	7,5E+03	9,8E+03	1,2E+04	1,4E+04	1,5E+04	1,3E+04	1,5E+04	1,3E+04	1,2E+04	1,5E+04	1,6E+04
% of all installations	72	69	74	65	68	76	82	80	81	79	82	80	77	81	80
Nuclear Power Plants (TBq)	2,2E+03	2,2E+03	2,3E+03	2,7E+03	3,4E+03	3,0E+03	2,7E+03	3,3E+03	3,4E+03	3,4E+03	3,3E+03	3,2E+03	3,5E+03	3,6E+03	3,8E+03
% of all installations	27	30	26	35	31	24	18	19	19	21	18	20	22	19	19
Nuclear Fuel Fabrication (TBq)		-	-	-	-	-	-	-	-	-	-	-	-	-	-
% of all installations		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Research and Development Facilities (TBq)	6,1E+01	1,0E+02	3,2E+01	2,4E+01	8,8E+01	1,2E+02	1,7E+01	1,5E+01	1,6E+01	1,4E+01	1,6E+01	7,0E+00	5,8E+00	1,2E+01	1,8E+01
% of all installations	1	1,4	0,37	0,31	0,81	0,91	0,11	0,089	0,089	0,086	0,085	0,042	0,037	0,062	0,092
Decommissioning (TBq)															
% of all installations															

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
All Nuclear Installations (TBq)	2,1E+04	1,9E+04	1,6E+04	1,6E+04	1,1E+04	1,4E+04	1,4E+04	1,3E+04	1,6E+04	1,8E+04	1,7E+04	1,8E+04	1,8E+04	1,6E+04	1,6E+04
Reprocessing Plants (TBq)	1,7E+04	1,5E+04	1,2E+04	1,3E+04	9,0E+03	1,1E+04	1,1E+04	1,1E+04	1,3E+04	1,5E+04	1,4E+04	1,5E+04	1,4E+04	1,3E+04	1,3E+04
% of all installations	83	81	79	81	80	78	80	81	80	81	82	86	81	81	80
Nuclear Power Plants (TBq)	3,6E+03	3,4E+03	3,4E+03	2,9E+03	2,2E+03	2,9E+03	2,8E+03	2,5E+03	3,2E+03	3,4E+03	3,0E+03	2,8E+03	3,3E+03	3,1E+03	3,2E+03
% of all installations	17	19	22	19	20	22	20	18	20	19	18	16	19	19	20
Nuclear Fuel Fabrication (TBq)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
% of all installations	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Research and Development Facilities (TBq)	7,0E+00	1,8E+01	5,4E+00	7,0E+00	6,7E+00	4,7E+00	1,4E+01	5,0E+00	2,5E+00	5,7E+00	6,1E+00	3,9E+00	3,0E+00	3,0E+00	1,9E+00
% of all installations	0,034	0,095	0,035	0,045	0,06	0,035	0,1	0,037	0,016	0,031	0,036	0,022	0,017	0,019	0,012
Decommissioning (TBq)			1,7E+01	2,5E+01	1,1E+01	1,9E+00	8,1E-01	6,0E+00	2,8E+01	2,8E+01	1,7E+01	5,2E+01	3,4E+01	2,3E+01	2,3E+01
% of all installations			0,11	0,16	0,10	0,014	0,0057	0,045	0,17	0,15	0,1	0,3	0,2	0,1	0,1

Table 3. Total beta (excl. tritium) discharges 1989-2018

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
All Nuclear Installations (TBq)	9,3E+02	4,9E+02	2,3E+02	2,7E+02	2,5E+02	3,2E+02	3,7E+02	3,3E+02	3,2E+02	2,6E+02	2,6E+02	1,7E+02	2,3E+02	2,3E+02	2,0E+02	2,0E+02	1,1E+02	5,8E+01	3,3E+01	2,7E+01	2,6E+01	2,3E+01	2,6E+01	2,0E+01	2,1E+01	2,1E+01	2,0E+01	2,2E+01	2,3E+01	1,7E+01
Reprocessing Plants (TBq)	6,9E+02	3,8E+02	1,8E+02	1,3E+02	1,7E+02	2,0E+02	2,4E+02	1,7E+02	1,7E+02	1,1E+02	1,3E+02	9,8E+01	1,4E+02	1,2E+02	9,7E+01	8,6E+01	5,4E+01	3,7E+01	3,0E+01	2,1E+01	1,8E+01	1,5E+01	1,8E+01	1,2E+01	9,9E+00	1,1E+01	1,2E+01	9,8E+00	1,2E+01	7,4E+00
% of all installations	74	78	78	50	67	61	66	51	53	42	49	57	61	53	49	42	52	63	89	76	68	64	70	61	47	52	62	44	54	44
Nuclear Power Plants (TBq)	7,6E+00	1,0E+01	3,8E+00	8,9E+00	1,1E+01	2,8E+00	3,4E+00	5,2E+00	7,4E+00	2,0E+00	2,0E+00	3,0E+00	4,2E+00	3,6E+00	3,2E+00	1,3E+00	2,0E+00	7,5E-01	4,6E-01	1,5E+00	2,1E+00	3,2E+00	2,2E+00	2,7E+00	4,6E+00	3,7E+00	3,4E+00	5,5E+00	5,5E+00	3,6E+00
% of all installations	1	2,1	1,7	3,3	4,4	0,86	0,94	1,6	2,3	0,76	0,78	1,7	1,8	1,5	1,6	0,64	1,9	1,3	1,4	5,6	7,9	14	8,6	14	21,90	17,62	16,90	25,02	24,42	21,51
Nuclear Fuel Fabrication (TBq)	1,1E+02	9,2E+01	3,9E+01	1,2E+02	6,3E+01	1,1E+02	1,1E+02	1,5E+02	1,4E+02	1,5E+02	1,3E+02	7,1E+01	8,5E+01	1,1E+02	9,7E+01	1,2E+02	1,0E+02	2,1E+01	3,0E+00	4,6E+00	3,3E+00	4,5E+00	5,0E+00	4,5E+00	2,7E+00	2,9E+00	1,8E+00	1,7E+00	8,4E-01	2,8E-01
% of all installations	12	19	17	45	25	36	31	45	44	57	50	41	37	45	49	57	98	35	8,9	17	12	19	19	23	13	14	9	8	4	2
Reserch and Development Facilities (TBq)	1,2E+02	4,5E+00	6,3E+00	6,6E+00	8,2E+00	9,1E+00	7,0E+00	8,1E+00	9,9E-01	6,6E-01	3,6E-01	3,0E-01	4,6E-01	4,6E-01	4,4E-01	4,7E-01	9,5E-02	6,2E-02	1,3E-01	6,7E-02	2,3E+00	1,8E-02	1,5E-02	6,7E-04	6,4E-04	1,4E-01	6,6E-01	8,8E-03	6,1E-04	7,6E-03
% of all installations	13	0,91	2,8	2,5	3,2	2,8	1,9	2,4	0,31	0,25	0,14	0,17	0,2	0,2	0,22	0,23	0,09	0,11	0,4	0,25	8,7	0,08	0,06	0,0033	0,0030	0,65	3,31	0,04	0,00	0,05
Decommissioning (TBq)																		4,0E-01	4,1E-02	3,8E-01	8,0E-01	5,9E-01	5,9E-01	5,4E-01	3,2E-01	2,8E+00	2,1E+00	5,1E+00	4,0E+00	5,5E+00
% of all installations																		0,019	0,12	1,4	3,0	2,6	2,3	2,7	2	13	10	23	18	33

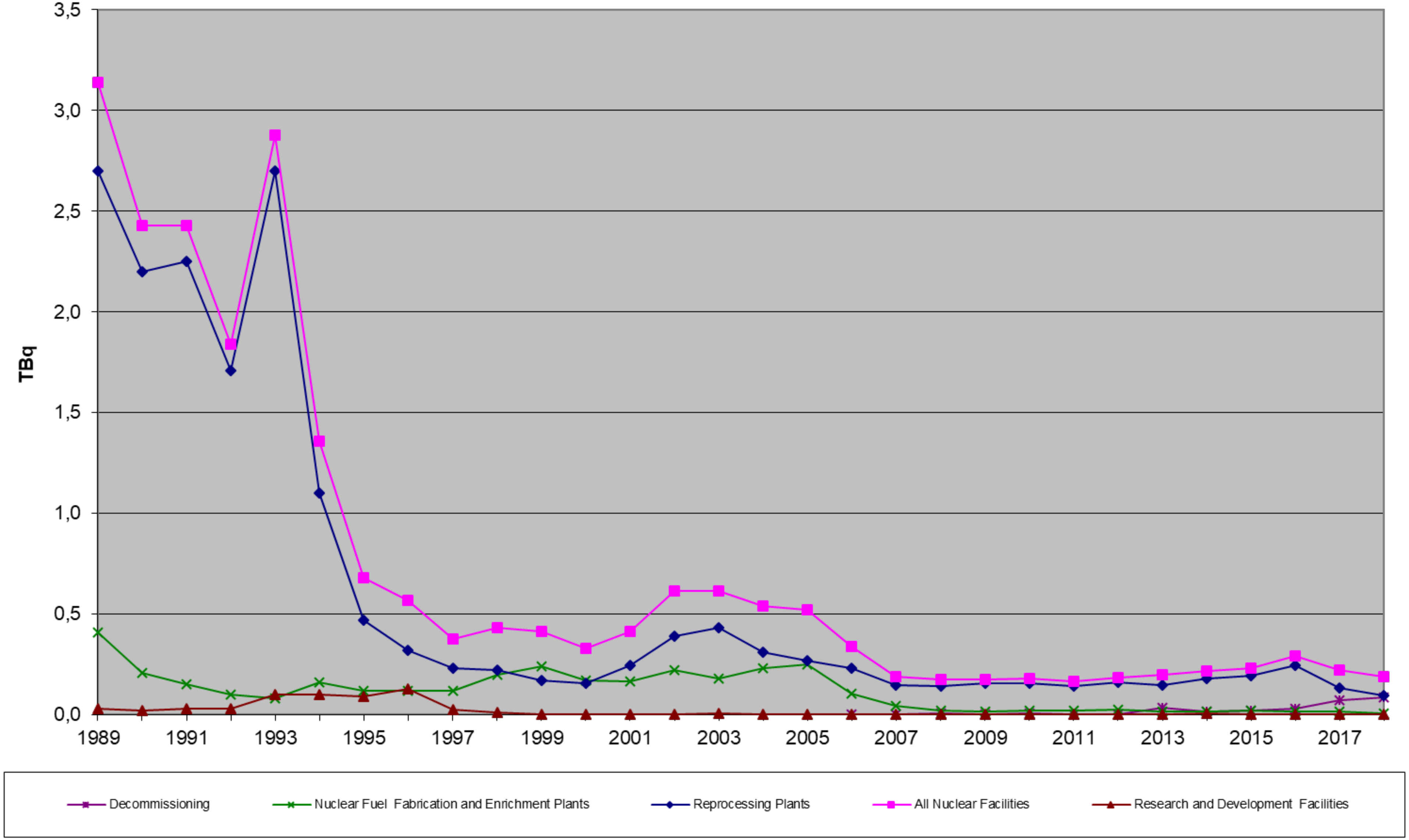


Figure 1. Total alpha activity discharge 1989 – 2018

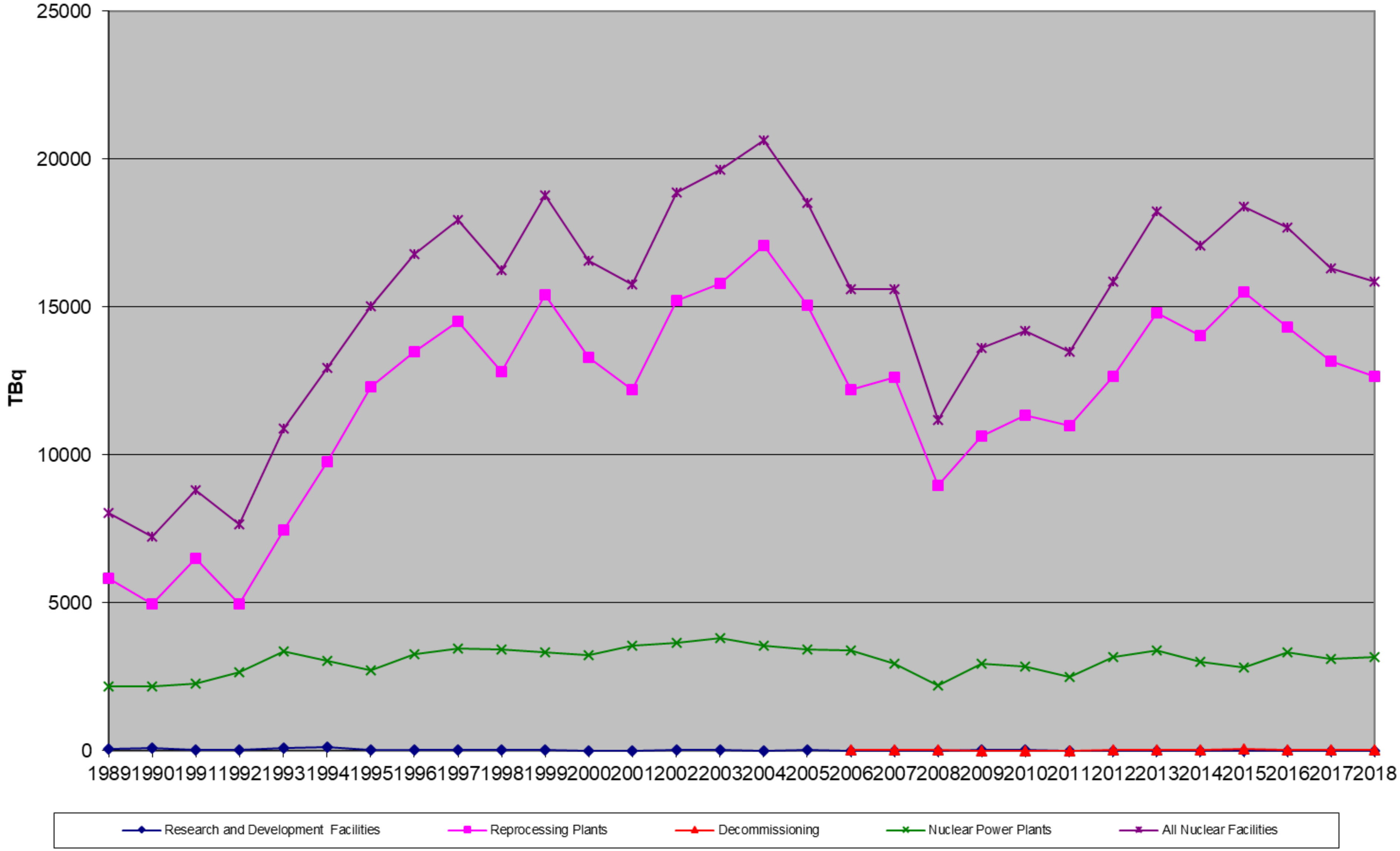


Figure 2. Discharge of tritium 1989 – 2018

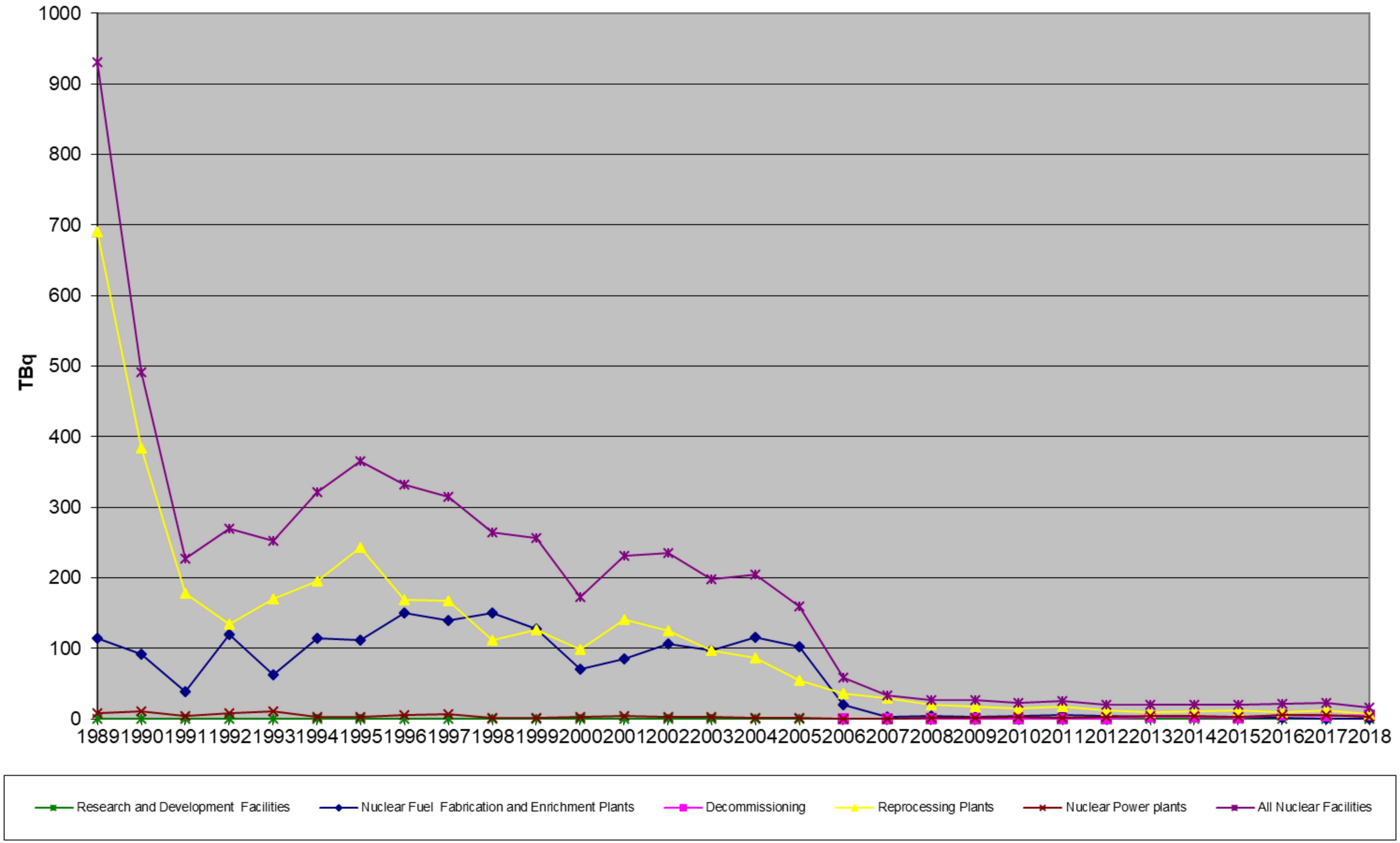


Figure 3. Total beta discharge 1989 - 2018

3. 2018 data and information

This section presents information on the location of the nuclear installations and data and information on liquid discharges for each OSPAR Contracting Party under the following categories of nuclear installations draining into the OSPAR Maritime Area:

Table 4: Nuclear Power Stations;

Table 5: Nuclear Fuel Reprocessing Plants;

Table 6: Nuclear Fuel Fabrication and Enrichment Plants;

Table 7: Research and Development Facilities;

Table 8: Discharges from Decommissioning and Treatment/Recovery of Old Radioactive Waste.

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 (OSPAR Agreement No. 2013/10). 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.

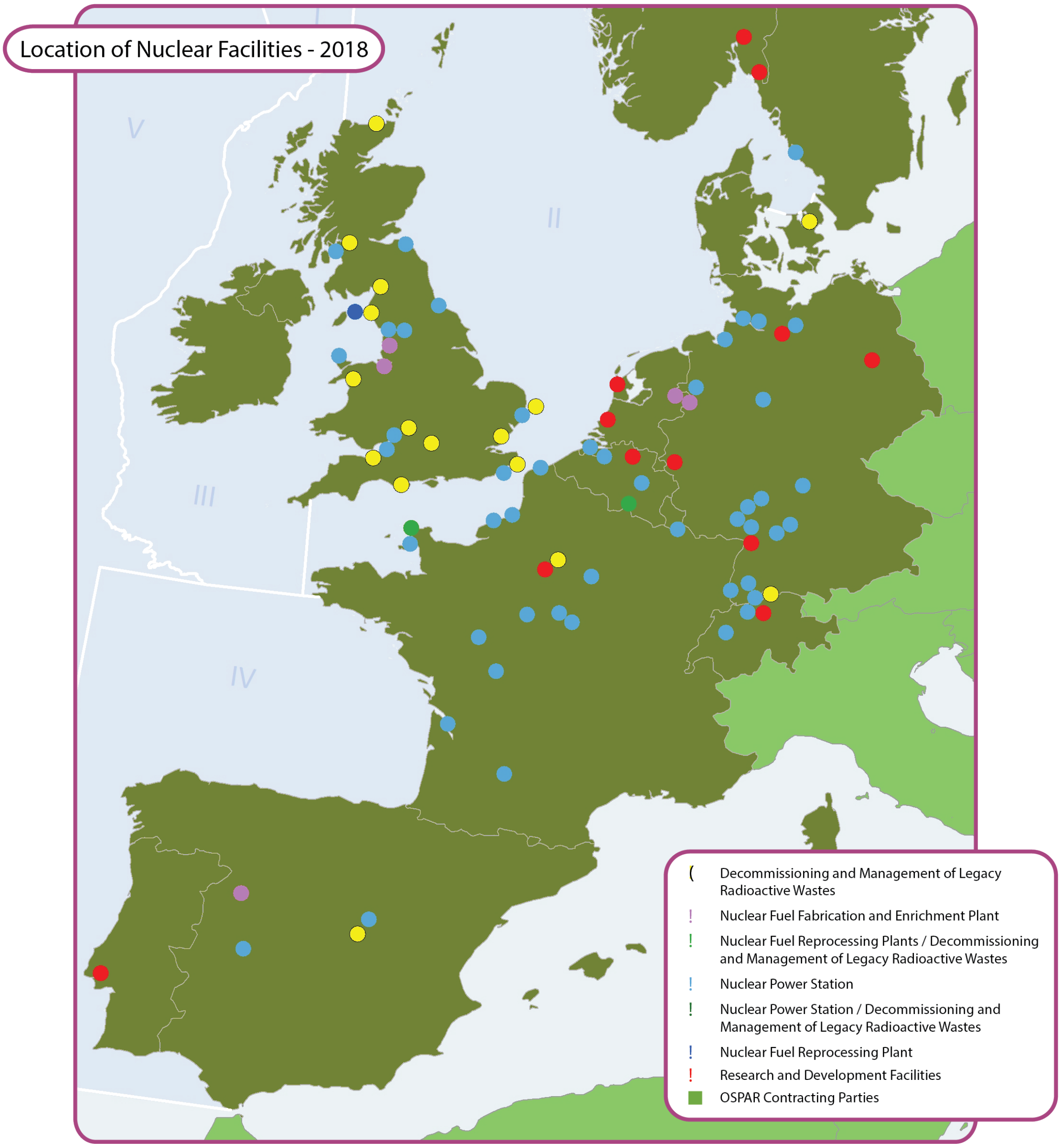
For radionuclides:

Ag:	Silver	Gd:	Gadolinium	Rh:	Rhodium
Am:	Americium	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 Map of nuclear installations

The map shows the location of nuclear facilities in OSPAR countries discharging directly or indirectly to the OSPAR Maritime Area.



3.2 Location of nuclear installations

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

Country / Code	Name of installation	Type	Discharging into
Belgium			
BE1	Doel	NPS	Schelde
BE2	Tihange	NPS	Meuse
BE3	Mol	RDF	River Mol-Neet
Denmark			

Country / Code	Name of installation	Type	Discharging into
DK1	Risø	DMLRW	Kattegat through Roskilde Fjord
France			
FR1	Belleville	NPS	Loire
FR3	Cattenom	NPS	Mosel
FR4	Chinon	NPS	Loire
FR5	Chooz	NPS/ DMLRW	Meuse
FR6	Dampierre en-Burly	NPS	Loire
FR7	Fessenheim	NPS	Rhine
FR8	Flamanville	NPS	Channel
FR9	Golfech	NPS	Garonne
FR10	Gravelines	NPS	North Sea
FR11	Nogent-sur-Seine	NPS	Seine
FR12	Paluel	NPS	Channel
FR13	Penly	NPS	Channel
FR14	Saint Laurent	NPS	Loire
FR15	La Hague	NFRP/ DMLRW	English Channel
FR16	Civaux	NPS	Vienne
FR17	Fontenay-aux-Roses	DMLRW	Seine
FR18	Le Blayais	NPS	Gironde Estuary
FR19	Saclay	RDF	Etang de Saclay
Germany			
DE1a	Biblis A	DMLRW	Rhine
DE1b	Biblis B	DMLRW	Rhine
DE2	Brokdorf	NPS	Elbe
DE3	Brunsbüttel	DMLRW	Elbe
DE4	Grafenrheinfeld	NPS	Main
DE5	Grohnde/Emmerthal	NPS	Weser
DE8a	Krümmel/Geesthacht	DMLRW	Elbe
DE8b	Geesthacht	RDF	Elbe
DE9a	Lingen/Emsland	NPS	Ems
DE9b	Lingen	DMLRW	Ems - via municipal sewer system
DE10	Mülheim-Kärlich	DMLRW	Rhine
DE11a	Neckarwestheim 1	DMLRW	Neckar
DE11b	Neckarwesheim 2	NPS	Neckar
DE12	Obrigheim	DMLRW	Neckar
DE13a	Philippsburg KKP1	DMLRW	Rhine
DE13b	Philippsburg KKP2	NPS	Rhine
DE14	Rheinsberg	DMLRW	Havel
DE15	Stade	DMLRW	Elbe
DE16	Rodenkirchen-Unterweser	DMLRW	Weser
DE17	Würgassen/Beverungen	DMLRW	Weser
DE18	Karlsruhe	RDF	Rhine
DE19	Gronau	NFFEP	Vechte, IJsselmeer
DE24	HMI Berlin	RDF	Havel
DE25	Jülich	RDF	Rur
The Netherlands			
NL1	Borssele	NPS	Scheldt Estuary
NL3	Almelo	NFFEP	Municipal sewer system

Country / Code	Name of installation	Type	Discharging into
NL4	Delft	RDF	Sewage system
NL5	Petten	RDF	North Sea
Norway			
NO1	Halden	RDF	River Tista (Skagerrak)
NO2	Kjeller	RDF	River Nitelva (Skagerrak)
Portugal			
PT1	Campus de Sacavém	RDF	Tagus River
Spain			
ES1	Almaraz	NPS	Tagus
ES2	José Cabrera	DMLRW	Tagus
ES3	Trillo	NPS	Tagus
ES4	Juzbado	NFFEP	River Tormes - Duero
Sweden			
SE2	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			
UK1	Berkeley	DMLRW	Severn Estuary
UK2	Bradwell	DMLRW	North Sea
UK4	Chapelcross	DMLRW	Solway Firth
UK5a	Dungeness A	DMLRW	English Channel
UK5b	Dungeness B	NPS	English Channel
UK6	Hartlepool	NPS	North Sea
UK7a	Heysham 1	NPS	Morecambe Bay
UK7b	Heysham 2	NPS	Morecambe Bay
UK8a	Hinkley Point A	DMLRW	Severn Estuary
UK8b	Hinkley Point B	NPS	Severn Estuary
UK9a	Hunterston A	DMLRW	Firth of Clyde
UK9b	Hunterston B	NPS	Firth of Clyde
UK10	Oldbury	DMLRW	Severn Estuary
UK11a	Sizewell A	DMLRW	North Sea
UK11b	Sizewell B	NPS	North Sea
UK12	Torness	NPS	North Sea
UK13	Trawsfynydd	DMLRW	Trawsfynydd lake
UK14	Wylfa	NPS	Irish Sea
UK15	Sellafield	NFRP and DMLRW	Irish Sea
UK16	Capenhurst	NFFEP	Irish Sea via Rivacre Brook and Mersey Estuary
UK17	Springfields	NFFEP	Irish Sea via River Ribble
UK18	Dounreay	DMLRW	Pentland Firth
UK19	Harwell	DMLRW	River Thames
UK20	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: Decommissioning and Management of Legacy Radioactive Wastes

Table 4: Nuclear Power Stations (in TBq/y)

Location Ref	Site	Discharges to	Reactors Number and Type	Installed Capacity MW.h	Net Electrical Output MW	Calculated Total-a	Calculated Total-b	Tritium	other radio nuclides	total a-activity	total b-activity (ex.Tritium)
BE01	Doel	Schelde	4 PWR	2911	11792767	4.05E-06	2.01E-03	3.51E+01	8.41E-04	4.05E-06	3.04E-04
BE02	Tihange	Meuse	3 PWR	962	7622140	3.03E-07	4.02E-04	2.84E-01	8.99E-05	3.03E-07	1.06E-04
BE02	Tihange	Meuse		1008	5455497	2.30E-06	1.78E-02	3.18E+01	5.23E-04	2.30E-06	7.47E-03
BE02	Tihange	Meuse		1046	2125223	8.82E-07	2.31E-03	1.36E+01	8.22E-05	8.82E-07	9.80E-04
CH01	Beznau	Aare	2 PWR	365/365	5538400	8.10E-08	1.80E-04	7.10E+00	1.80E-04	8.10E-08	1.80E-04
CH02	Gösgen	Aare	1 PWR	1010	8246750	7.00E-08	1.20E-05	1.70E+01	1.20E-05	7.00E-08	1.20E-05
CH03	Leibstadt	Rhine	1 BWR	1220	7799180	2.00E-07	1.20E-04	5.00E-01	1.20E-04	2.00E-07	1.20E-04
CH04	Mühleberg	Aare	1 BWR	373	2953653	2.10E-08	6.90E-05	1.10E-01	6.90E-05	2.10E-08	6.90E-05
CH06	ZWILAG Würenlingen	Aare				2.80E-09	3.30E-04	2.60E-02	3.30E-04	2.80E-09	3.30E-04
DE02	Brokdorf	Elbe	1 PWR	1480	9840000	ND	ND	2.41E+01	ND	ND	ND
DE05	Grohnde/Emmerthal	Weser	1 PWR	1430	10300000	ND	ND	2.03E+01	ND	ND	ND
DE09a	Lingen/EmslaND	Ems	1 PWR	1406	10900000	ND	ND	1.20E+01	ND	ND	ND
DE11b	Neckar-Westheim 2	Neckar	1 PWR	1400	9100000	ND	ND	1.59E+01	ND	ND	ND
DE13b	Philippsburg 2	Rhine	1 PWR	1468	10300000	ND	2.35E-05	1.36E+01	2.35E-05	ND	2.35E-05
ES01	Almaraz	Tagus	2 PWR	2094	15698898		8.26E-03	3.51E+01	8.26E-03		
ES03	Trillo	Tagus	1 PWR	1066	7732002		1.94E-04	2.24E+01	1.94E-04		
FR01	Belleville	Loire	2 PWR	2600	329000000		4.30E-04	5.06E+01	4.30E-04		
FR03	Cattenom	Mosel	4 PWR	5200	329000000		8.30E-04	9.90E+01	8.30E-04		
FR04	Chinon	Loire	4 PWR	3600	329000000		3.10E-04	5.07E+01	3.10E-04		
FR05	Chooz	Meuse	2 PWR	2900	329000000		7.10E-04	5.55E+01	7.10E-04		
FR06	Dampierre-en-Burly	Loire	4 PWR	3600	329000000		8.10E-04	4.88E+01	8.10E-04		
FR07	Fessenheim	Rhine	2 PWR	1800	329000000		4.10E-04	3.12E+01	4.10E-04		
FR08	Flamanville	North Sea (Channel)	2 PWR	2600	329000000		3.40E-04	4.66E+01	3.40E-04		
FR09	Golfech	Garonne	2 PWR	2600	329000000		3.00E-04	6.35E+01	3.00E-04		
FR10	Gravelines	North Sea	6 PWR	5400	329000000		2.88E-03	7.06E+01	2.88E-03		
FR11	Nogent-sur-Seine	Seine	2 PWR	2600	329000000		3.30E-04	5.40E+01	3.30E-04		
FR12	Paluel	North Sea (Channel)	4 PWR	5200	329000000		1.10E-03	9.50E+01	1.10E-03		
FR13	Penly	North Sea (Channel)	2 PWR	2600	329000000		4.80E-04	5.52E+01	4.80E-04		
FR14	Saint Laurent	Loire	2 PWR	1800	329000000		2.30E-04	2.34E+01	2.30E-04		
FR16	Civaux	Vienne	2 PWR	2900	329000000		3.30E-04	6.99E+01	3.30E-04		
FR18	Le Blayais	Gironde Estuary	4 PWR	3600	329000000		6.40E-04	4.66E+01	6.40E-04		
NL01	Borssele	Scheldt Estuary	1 PWR	520	3325000		3.43E-05	5.10E+00		ND	3.43E-05
SE02	Ringhals 1- 4	Kattegat	1 BWR	881	6600000	1.05E-07	1.14E-04	4.60E-01	4.30E-05	1.05E-07	1.14E-04
SE02	Ringhals 1- 4	Kattegat	1 PWR	865	6700000	2.19E-07	7.95E-05	1.00E+01	5.32E-05	2.19E-07	7.95E-05
SE02	Ringhals 1- 4	Kattegat	1 PWR	1063	8100000	1.36E-07	4.98E-04	1.10E+01	3.38E-04	1.36E-07	4.98E-04
SE02	Ringhals 1- 4	Kattegat	1 PWR	1123	8700000	1.32E-07	1.46E-04	1.60E+01	7.33E-05	1.32E-07	1.46E-04
UK05b	Dungeness B	English Channel	2 AGR	520	3100		2.95E-01	2.56E+02	2.73E-03		
UK06	Hartlepool	North Sea	2 AGR	595	3150		1.51E+00	4.02E+02	1.32E-03		
UK07a	Heysham 1	Morecambe Bay	2 AGR	580	3150		4.01E-01	3.19E+02	5.04E-03		
UK07b	Heysham 2	Morecambe Bay	2 AGR	610	3400		1.79E-01	3.55E+02	1.34E-02		
UK08b	Hinkley Point B	Severn Estuary	2 AGR	475	2640		2.91E-01	2.36E+02	3.24E-03		
UK09b	Hunterston B	Firth of Clyde	2 AGR	475	2640	2.08E-05	3.36E-01	1.48E+02	5.14E-03	2.08E-05	
UK11b	Sizewell B	North Sea	1 PWR	1198	3425		4.61E-03	1.12E+01	4.30E-03		
UK12	Torness	North Sea	2 AGR	590	3400	3.81E-06	5.33E-01	2.95E+02	4.34E-03	3.81E-06	
UK14	Wylfa	Irish Sea	2 GCR				0.00601	0.957	0.00601		

Table 4 cont…: Nuclear Power Stations (in TBq/y)

Location Ref	Site	Discharges to	Co58	Co60	Zn65	Sr90	Zr/Nb95	Ru106	Ag110m	Sb125	Cs134	Cs137	Ce144	S35
BE01	Doel	Schelde	3.71E-04	3.57E-04	4.78E-05	3.43E-06	6.50E-05	2.18E-05	1.98E-04	8.27E-04	2.29E-05	2.41E-04	1.33E-04	
BE02	Tihange	Meuse	5.27E-05	1.36E-04	1.09E-05	6.39E-07	2.16E-05	2.65E-05	6.92E-05	7.80E-06	4.27E-06	3.23E-05	1.74E-05	
BE02	Tihange	Meuse	7.54E-04	8.98E-03	4.28E-05	4.14E-06	2.18E-04	1.39E-04	1.36E-03	3.54E-04	1.49E-05	2.07E-04	3.97E-05	
BE02	Tihange	Meuse	6.30E-05	1.17E-03	1.00E-05	1.84E-06	2.16E-05	3.09E-05	1.04E-04	9.73E-05	4.36E-06	9.18E-05	1.12E-05	
CH01	Beznau	Aare	3.00E-06	5.40E-05	2.30E-07	1.30E-06			2.70E-06	1.80E-05	1.20E-06	8.10E-05		
CH02	Gösgen	Aare	9.30E-08	8.30E-07			9.10E-08							
CH03	Leibstadt	Rhine		1.10E-04								2.40E-06		
CH04	Mühleberg	Aare	4.70E-06	4.10E-05	1.80E-06	2.50E-08						1.10E-06		
CH06	ZWILAG Würenlingen	Aare	2.10E-08	1.70E-05		1.20E-07				2.80E-05	5.10E-06	2.80E-04		
DE02	Brokdorf	Elbe	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
DE05	Grohnde/Emmerthal	Weser	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
DE09a	Lingen/EmslaND	Ems	ND	ND	ND	ND	ND	ND	ND	ND	ND	6.16E-08	ND	
DE11b	Neckar-Westheim 2	Neckar	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
DE13b	Philippsburg 2	Rhine	2.89E-06	1.28E-05	ND	ND	1.00E-07	ND	2.00E-07	ND	ND	3.11E-06	2.80E-07	
ES01	Almaraz	Tagus	1.87E-03	9.80E-04	3.56E-05	3.02E-05	5.62E-04	1.28E-04	1.02E-03	4.12E-04	9.97E-05	5.41E-04		
ES03	Trillo	Tagus	2.57E-06	2.04E-05			2.47E-06		2.44E-06			2.32E-06		
FR01	Belleville	Loire	3.80E-05	1.27E-04					1.27E-04	4.40E-05	1.50E-05	1.80E-05		
FR03	Cattenom	Mosel	1.81E-04	2.67E-04					1.34E-04	6.40E-05	2.30E-05	4.60E-05		
FR04	Chinon	Loire	4.20E-05	9.10E-05					5.10E-05	4.30E-05	1.30E-05	1.50E-05		
FR05	Chooz	Meuse	6.90E-05	3.74E-04					1.15E-04	2.10E-05	1.20E-05	1.70E-05		
FR06	Dampierre-en-Burly	Loire	1.10E-04	2.48E-04					2.93E-04	3.40E-05	1.20E-05	1.70E-05		
FR07	Fessenheim	Rhine	4.00E-06	7.20E-05					2.83E-04	1.60E-05	5.00E-06	6.00E-06		
FR08	Flamanville	North Sea (Channel)	1.18E-04	1.08E-04					2.70E-05	1.70E-05	5.00E-06	6.00E-06		
FR09	Golfech	Garonne	5.60E-05	7.10E-05					1.80E-05	5.70E-05	1.10E-05	1.20E-05		
FR10	Gravelines	North Sea	5.91E-04	8.29E-04					8.07E-04	1.09E-04	3.30E-05	5.60E-05		
FR11	Nogent-sur-Seine	Seine	6.00E-05	8.50E-05					1.40E-05	3.80E-05	3.80E-05	3.00E-05		
FR12	Paluel	North Sea (Channel)	2.69E-04	6.02E-04					1.80E-05	5.00E-05	1.20E-05	8.50E-05		
FR13	Penly	North Sea (Channel)	1.05E-04	2.46E-04					1.70E-05	1.80E-05	7.00E-06	1.30E-05		
FR14	Saint Laurent	Loire	3.10E-05	6.00E-05					6.00E-05	1.90E-05	7.00E-06	9.00E-06		
FR16	Civaux	Vienne	1.90E-05	9.20E-05					5.40E-05	1.00E-05	4.60E-05	6.70E-05		
FR18	Le Blayais	Gironde Estuary	1.38E-04	1.07E-04					8.70E-05	2.08E-04	1.20E-05	1.50E-05		
NL01	Borssele	Scheldt Estuary	2.72E-07	1.82E-05	2.72E-08	ND	1.64E-06	ND	1.02E-07	ND	ND	1.07E+06	ND	NI
SE02	Ringhals 1- 4	Kattegat	9.40E-06	4.10E-05	5.20E-07	4.40E-07	1.00E-05		4.00E-06	4.10E-06		2.50E-06		
SE02	Ringhals 1- 4	Kattegat	1.20E-05	4.00E-06		5.60E-07	3.26E-07		7.00E-06	1.50E-06		1.10E-06		
SE02	Ringhals 1- 4	Kattegat	7.00E-05	1.90E-05		5.60E-08	1.40E-06		3.80E-05	3.20E-05		8.90E-08		
SE02	Ringhals 1- 4	Kattegat	6.40E-05	3.50E-06			1.60E-07		4.00E-06	2.50E-06		4.20E-07		
UK05b	Dungeness B	English Channel		8.52E-04								2.04E-03		2.89E-01
UK06	Hartlepool	North Sea		2.21E-04								3.38E-03		1.51E+00
UK07a	Heysham 1	Morecambe Bay		2.25E-04								6.29E-04		3.95E-01
UK07b	Heysham 2	Morecambe Bay		1.02E-04								7.84E-04		1.65E-01
UK08b	Hinkley Point B	Severn Estuary		9.95E-05								5.56E-04		2.87E-01
UK09b	Hunterston B	Firth of Clyde		4.70E-04										3.30E-01
UK11b	Sizewell B	North Sea										3.12E-04		
UK12	Torness	North Sea		3.63E-04										5.28E-01
UK14	Wylfa	Irish Sea												

Table 5: Nuclear Fuel Reprocessing Plants (operational discharges) (in TBq/y)

Location Ref	Site	Discharges to	Type of fuel reprocessed	Capacity (t/y)	Tritium	Total-a	Total-b	C14
FR15	La Hague	English Channel	PWR, BWR	1.60E+03	1.14E+04	1.61E-02	2.30E+00	7.62E+00
UK15	Sellafield	Irish Sea	Magnox, AGR, LWR		1.26E+03	7.91E-02	5.07E+00	2.91E+00

Location Ref	Site	Discharges to	Mn54	Co57	Co58	Co60	Ni63	Zn65	Sr90
FR15	La Hague	English Channel	2.76E-03	6.92E-05	5.51E-04	8.17E-02	4.26E-02	1.41E-04	8.50E-02
UK15	Sellafield	Irish Sea				1.14E-02			2.53E-01

Location Ref	Site	Discharges to	(Zr + Nb95)	Tc99	Ru106	(Ru + Rh) 106	Sb125	I129	Cs134
FR15	La Hague	English Channel		3.74E-02	1.10E+00	2.20E+00	4.36E-02	1.30E+00	4.73E-02
UK15	Sellafield	Irish Sea	1.99E-02	7.30E-01	5.37E-01			2.45E-01	3.47E-02

Location Ref	Site	Discharges to	Cs137	Ce144	(Ce + Pr) 144	Eu154	Eu155	Np237	Pu239+240
FR15	La Hague	English Channel	6.22E-01	3.08E-04	6.15E-04	6.71E-04	9.96E-05	2.64E-04	1.18E-03
UK15	Sellafield	Irish Sea	2.22E+00	9.00E-02				3.84E-02	7.63E-02

Location Ref	Site	Discharges to	Pu241	Am241	Cm242	Cm 243+244	Uranium (kg)
FR15	La Hague	English Channel	1.12E-01	1.90E-03	1.54E-05	1.56E-03	1.82E+01
UK15	Sellafield	Irish Sea	1.26E+00	5.22E-03		1.46E-03	

Table 6: Nuclear Fuel Fabrication and Enrichment Plants (operational discharges) (in TBq/y)

Location Ref	Site	Discharges to	Type of Fuel	Capacity (t/y)	Production	Calculated Total-a	Calculated Total-b	Activity	TBq released
DE19	Gronau, Urenco	Dinkel via municipal sewer system	Uranium enrichment	3.90E+03	3.81E+03	1.29E-08	3.47E-09	Total-a	1.29E-08
DE19	Gronau, Urenco	Dinkel via municipal sewer system	Uranium enrichment					Total-b (excluding tritium)	3.47E-09
DE19	Gronau, Urenco	Dinkel via municipal sewer system	Uranium enrichment					Uranium-a	2.34E-09
ES04	Juzbado	River Tormes - Duero	PWR, BWR	5.00E+02	2.76E+02	1.79E-05		Total-a	1.79E-05
NL03	Urenco, Almelo	Municipal sewer system	Uranium enrichment			7.00E-07	1.70E-06	Total-a	7.00E-07
NL03	Urenco, Almelo	Municipal sewer system	Uranium enrichment					Total-b (excluding tritium)	1.70E-06
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment			0.00001502	0.00000188	Uranium-a	0.00000177
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment					Uranium daughters	0.00000382
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment					Other-a	0.00000943
UK16	Capenhurst	Irish Sea via Rivacre Brook and Mersey Estuary	Uranium enrichment					Tc99	0.00000188
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication			0.0078	0.28	Total-a	0.0078
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Total-b (excluding tritium)	0.28
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Uranium-a	0.0065
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Other-a	0.00224
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Tc99	0.0079
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Th230	0.00045
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Th232	0.000133
UK17	Springfields	Irish Sea via River Ribble	GCR, AGR, PWR fuel fabrication					Np237	0.000336

Table 7: Research and Development Facilities (operational discharges) (in TBq/y)

Location Ref	Site	Discharges to	Reactors Number and Type	Installed Capacity	Calculated Total-a	Calculated Total-b	Radionuclides	TBq released per annum
BE03	Mol	River Mol-Neet	2				Co60	8.40E-06
BE03	Mol	River Mol-Neet	2				Cs134	8.25E-06
BE03	Mol	River Mol-Neet	2				Cs137	1.30E-04
BE03	Mol	River Mol-Neet	2				Sr90/Y90	6.23E-05
BE03	Mol	River Mol-Neet	2				Total activitiy	8.11E-01
BE03	Mol	River Mol-Neet	2	1.29E+02	2.07E-05		Total-a	2.07E-05
BE03	Mol	River Mol-Neet	2			2.50E-04	Total-b	4.09E-05
BE03	Mol	River Mol-Neet	2				Tritium	8.11E-01
CH05	Paul Scherrer Institute	Aare			8.00E-08		a-emitting radionuclides	
CH05	Paul Scherrer Institute	Aare					Ag110m	2.40E-08
CH05	Paul Scherrer Institute	Aare					Au195	7.00E-07
CH05	Paul Scherrer Institute	Aare					Ba133	1.90E-08
CH05	Paul Scherrer Institute	Aare				3.23E-04	b-and g-emitting radionuclides	
CH05	Paul Scherrer Institute	Aare					Be7	2.80E-05
CH05	Paul Scherrer Institute	Aare					Bi207	5.60E-08
CH05	Paul Scherrer Institute	Aare					Co56	8.60E-08
CH05	Paul Scherrer Institute	Aare					Co57	7.30E-07
CH05	Paul Scherrer Institute	Aare					Co58	3.90E-07
CH05	Paul Scherrer Institute	Aare					Co60	1.10E-06
CH05	Paul Scherrer Institute	Aare					Cs134	3.30E-06
CH05	Paul Scherrer Institute	Aare					Cs137	2.30E-04
CH05	Paul Scherrer Institute	Aare					Ga67	6.90E-08
CH05	Paul Scherrer Institute	Aare					In111	8.30E-08
CH05	Paul Scherrer Institute	Aare					Lu172	3.80E-07
CH05	Paul Scherrer Institute	Aare					Lu173	1.80E-07
CH05	Paul Scherrer Institute	Aare					Lu177	3.20E-05
CH05	Paul Scherrer Institute	Aare					Mn54	2.60E-06
CH05	Paul Scherrer Institute	Aare					Na22	2.00E-06
CH05	Paul Scherrer Institute	Aare					Os185	8.90E-08
CH05	Paul Scherrer Institute	Aare					Pu238/Am241	2.20E-08
CH05	Paul Scherrer Institute	Aare					Pu239/240	2.20E-08
CH05	Paul Scherrer Institute	Aare					Rb83	1.20E-08
CH05	Paul Scherrer Institute	Aare					Sb124	3.10E-07
CH05	Paul Scherrer Institute	Aare					Sc46	1.00E-07
CH05	Paul Scherrer Institute	Aare					Se75	8.10E-08
CH05	Paul Scherrer Institute	Aare					Sr85	1.20E-08
CH05	Paul Scherrer Institute	Aare					Sr90/Y90	1.20E-05
CH05	Paul Scherrer Institute	Aare					Tb160	3.30E-08
CH05	Paul Scherrer Institute	Aare					Tb161	3.60E-06
CH05	Paul Scherrer Institute	Aare					Ti44	1.80E-08
CH05	Paul Scherrer Institute	Aare					Tritium	8.40E-02
CH05	Paul Scherrer Institute	Aare					U234/238	3.60E-08
CH05	Paul Scherrer Institute	Aare					Y88	4.60E-08
CH05	Paul Scherrer Institute	Aare					Yb169	6.60E-08
CH05	Paul Scherrer Institute	Aare					Zn65	4.90E-06
CH5	Paul Scherrer Institute	Aare					Cr51	3.30E-07

Table 7 cont…: Research and Development Facilities (operational discharges) (in TBq/y)

Location Ref	Site	Discharges to	Reactors Number and Type	Installed Capacity	Calculated Total-a	Calculated Total-b	Radionuclides	TBq released per annum
DE	Mainz	Rhine	1 TRIGA	100 kW (therm)		3.36E-07	Other radionuclides	3.36E-07
DE	Mainz	Rhine	1 TRIGA	100 kW (therm)	9.10E-09		Total a-activity	9.10E-09
DE	Mainz	Rhine	1 TRIGA	100 kW (therm)			Tritium	5.06E-06
DE08b	Geesthacht	Elbe	1			2.01E-06	Other radionuclides	2.01E-06
DE08b	Geesthacht	Elbe	1		1.23E-09		Total a-activity	1.23E-09
DE08b	Geesthacht	Elbe	1				Tritium	2.12E-05
DE18	Karlsruhe	Rhine	No reactors			2.00E-06	Other radionuclides	2.00E-06
DE18	Karlsruhe	Rhine	No reactors		1.78E-06		Total a-activity	1.78E-06
DE18	Karlsruhe	Rhine	No reactors				Tritium	1.20E-01
DE24	HMI Berlin	Havel	1			1.51E-08	Other radionuclides	1.51E-08
DE24	HMI Berlin	Havel	1				Total a-activity	ND
DE24	HMI Berlin	Havel	1				Tritium	5.65E-04
DE25	Jülich	Rur	1			1.41E-04	Other radionuclides	1.41E-04
DE25	Jülich	Rur	1		1.59E-05		Total a-activity	1.59E-05
DE25	Jülich	Rur	1				Tritium	3.62E-01
FR19	Saclay	Etang de Saclay	1 research reactor (Orphée)			1.70E-05	Other radionuclides	1.70E-05
FR19	Saclay	Etang de Saclay	1 research reactor (Orphée)		6.10E-05		Total-a	6.10E-05
FR19	Saclay	Etang de Saclay	1 research reactor (Orphée)				Tritium	8.10E-03
NL04	Delft	Sewage system	1 Research reactor	2 MWth			a-emitting radionuclides	ND
NL04	Delft	Sewage system	1 Research reactor	2 MWth			g-emitting radionuclides	5.70E-06
NL04	Delft	Sewage system	1 Research reactor	2 MWth			Total	
NL04	Delft	Sewage system	1 Research reactor	2 MWth		3.95E-06	Total-b	3.95E-06
NL05	Petten	North Sea	1 high flux and 1 low flux research reactor		1.40E-05		a-emitting radionuclides	1.40E-05
NL05	Petten	North Sea	1 high flux and 1 low flux research reactor	30kWth		6.80E-03	b/g-emitting radionuclides	6.80E-03
NL05	Petten	North Sea	1 high flux and 1 low flux research reactor				Total	
NL05	Petten	North Sea	1 high flux and 1 low flux research reactor	50 MWth			Tritium	2.10E-01
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Ag110m	5.00E-08
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Cd109	1.80E-07
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Ce141	7.10E-08
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Ce144	6.80E-08
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Co58	2.70E-07
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Co60	4.50E-06
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Cr51	1.10E-07
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Cs134	4.10E-07
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Cs137	1.80E-05
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				I131	5.60E-08
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Mn54	3.90E-10
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Mn56	NA

Table 7 cont…: Research and Development Facilities (operational discharges) (in TBq/y)

Location Ref	Site	Discharges to	Reactors Number and Type	Installed Capacity	Calculated Total-a	Calculated Total-b	Radionuclides	TBq released per annum
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Nb95	2.20E-07
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Sb125	2.40E-08
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Sr90	1.48E-06
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Total-a	NA
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator			2.63E-05	Total-b	2.63E-05
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Tritium	2.90E-01
NO01	Halden	River Tista (Skagerrak)	1 BWR D2O as moderator				Zr95	1.10E-07
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Ag110m	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Am241	4.70E-09
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Ce144	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Co58	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Co60	8.40E-07
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Cs134	1.20E-06
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Cs137	1.59E-05
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				I125	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				I131	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Pu238	1.60E-09
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Pu239/240	4.42E-08
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Pu241	NA
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Ru/Rh106	NA
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Ru103	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Ru106	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Sb125	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Sr90	3.80E-07
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor		6.75E-08		Total-a	6.75E-08
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor			1.85E-05	Total-b	1.85E-05
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Tritium	3.69E-03
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Zn65	
NO02	Kjeller	River Nitelva (Skagerrak)	1 JEEP II, heavy water and cooled research reactor				Zr/Nb95	

Table 8: Discharges associated with historical or legacy wastes (exceptional discharges) (in TBq/y)

Location Ref	Site	Discharges to	Facility type	Tritium	other radionuclides (1)	Calculated total-a	Calculated total-b	total a-activity	total b-activity (ex.Tritium)	C14	Co58	Co60	Zn65	Sr90
DE01a	Biblis A	Rhine	1 PWR	1.28E+00	6.25E-05	2.14E-08	6.25E-05	2.14E-08	6.25E-05		ND	4.29E-05	ND	ND
DE01b	Biblis B	Rhine	1 PWR	9.39E-01	1.71E-05	ND	1.71E-05	ND	1.71E-05		ND	6.11E-06	ND	ND
DE03	Brunsbüttel	Elbe	1 BWR	1.90E-04	1.69E-05	ND	1.69E-05	ND	1.69E-05		ND	2.72E-06	ND	2.52E-07
DE04	Grafenrheinfeld	Main	1 PWR	1.62E-02	5.57E-06	1.27E-10	5.57E-06	1.27E-10	5.57E-06		ND	3.15E-06	ND	ND
DE08a	Krümmel/Geesthacht	Elbe	1 BWR	7.70E-05	ND	1.23E-09	ND	1.23E-09	ND		ND	ND	ND	ND
DE09b	Lingen	Ems	1 BWR	1.19E-06	6.82E-20	1.35E-11	6.82E-20	1.35E-11	6.82E-20		ND	ND	ND	ND
DE10	Mülheim-Kärlich	Rhine	1 PWR	1.97E-05	6.06E-07	ND	6.06E-07	ND	6.06E-07		ND	1.61E-07	ND	ND
DE11a	Neckar-Westheim 1	Neckar	1 PWR	1.70E-01	ND	ND	ND	ND	ND		ND	ND	ND	ND
DE12	Obrigheim	Neckar	1 PWR	1.45E-03	3.31E-06	3.84E-08	3.31E-06	3.84E-08	3.31E-06		ND	9.28E-08	ND	ND
DE13a	Philippsburg 1	Rhine	1 BWR	2.86E-02	1.45E-05	2.86E-08	1.45E-05	2.86E-08	1.45E-05		1.86E-07	3.75E-06	ND	ND
DE14	Rheinsberg	Havel	1 PWR	ND	2.22E-06	1.00E-07	2.22E-06	1.00E-07	2.22E-06		ND	9.30E-08	ND	1.10E-07
DE15	Stade	Elbe	1 PWR											
DE16	Rodenkirchen/Unterw	Weser	1 PWR	3.29E+00	2.59E-05	9.92E-07	2.59E-05	9.92E-07	2.59E-05		ND	9.81E-06	ND	ND
DE17	Würgassen/Beverung	Weser	1 BWR											
DK01	Risø	Kattegat through F	No reactors	3.56E-03		1.50E-06	3.57E-03	1.50E-06	6.70E-06					
ES02	José Cabrera	Tagus	1PWR	1.03E-04	5.44E-04	6.57E-07	5.44E-04					3.85E-05		1.41E-05
FR04	Chinon	Loire	3 UNGG + 1 La	3.05E-05	1.37E-05		1.37E-05		1.37E-05	1.29E-05		2.51E-07		
FR05	Chooz	Meuse	1 PWR	3.43E-04	5.53E-04		5.53E-04		5.53E-04	2.14E-04		8.20E-06		3.27E-06
FR15	La Hague	English Channel	PWR + BWR			8.47E-04	1.81E-02	8.47E-04	1.81E-02			1.04E-07		4.14E-03
FR17	Fontenay-aux-Roses	Seine	No reactors	3.60E-06		4.00E-07	3.10E-07	4.00E-07	3.10E-07					
UK01	Berkeley	Severn	2 GCR	3.27E-06	1.20E-06		1.20E-06							
UK02	Bradwell	North Sea	2 GCR	Nil	Nil									
UK04	Chapelcross	Solway Firth	4 GCR	5.19E-03	2.37E-03	3.80E-06	2.37E-03	3.80E-06						
UK05a	Dungeness A	English Channel	2 GCR	2.40E-02	1.86E-02		1.86E-02							
UK08a	Hinkley Point A	Severn	2 GCR	7.90E-05	3.62E-04		3.62E-04							
UK09a	Hunterston A	Firth of Clyde	2 GCR	7.70E-05	5.09E-04	3.53E-04		3.53E-04						
UK10	Oldbury	Severn Estuary	2 GCR	1.51E-01	4.47E-02									
UK11a	Sizewell A	North Sea	2 GCR	3.50E-02	6.69E-02		6.69E-02							
UK13	Trawsfynydd	Trawsfynydd	2 GCR	6.10E-04	4.60E-04		4.60E-04							
UK15	Sellafield	Irish Sea	3 GCR, reproce	1.31E+01		8.26E-02	5.38E+00	8.26E-02	5.38E+00	1.88E-02		8.63E-03		1.03E+00
UK18	Dounreay	Pentland Firth	No reactors	1.80E-02	6.70E-03	1.50E-04		1.50E-04						3.90E-02
UK19	Harwell	River Thames	No reactors	2.14E-03		4.84E-06	2.19E-05	4.84E-06	2.19E-05			2.27E-07		
UK20	Winfrith	Weymouth Bay	No reactors	3.79E+00	2.70E-04	7.90E-06	7.02E-04	7.90E-06						

Table 8 cont…: Discharges associated with historical or legacy wastes (exceptional discharges) (in TBq/y)

Location Ref	Site	Discharges to	Sr90	Zr/Nb95	Tc99	Ru106	Ag110m	Sb125	I129	Cs134	Cs137	Ce144	Np237	Pu239/240	Pu241	Am241	Cm243/244
DE01a	Biblis A	Rhine	ND	ND		ND	ND	4.39E-06		ND	1.01E-05	ND					
DE01b	Biblis B	Rhine	ND	ND		ND	ND	ND		ND	1.29E-07	ND					
DE03	Brunsbüttel	Elbe	2.52E-07	ND		ND	ND	ND		ND	6.64E-06	ND					
DE04	Grafenrheinfeld	Main	ND	ND		ND	ND	2.57E-08		ND	ND	ND					
DE08a	Krümmel/Geesthacht	Elbe	ND	ND		ND	ND	ND		ND	ND	ND					
DE09b	Lingen	Ems	ND	ND		ND	ND	ND		ND	6.16E-20	ND					
DE10	Mülheim-Kärlich	Rhine	ND	ND		ND	ND	ND		ND	ND	ND					
DE11a	Neckar-Westheim 1	Neckar	ND	ND		ND	ND	ND		ND	ND	ND					
DE12	Obrigheim	Neckar	ND	ND		ND	ND	ND		ND	ND	ND					
DE13a	Philippsburg 1	Rhine	ND	ND		ND	2.10E-07	1.47E-06		ND	1.35E-18	ND					
DE14	Rheinsberg	Havel	1.10E-07	ND		ND	ND	ND		ND	5.60E-19	ND					
DE15	Stade	Elbe															
DE16	Rodenkirchen/Unterw	Weser	ND			ND	ND	1.45E-05		ND	1.61E-06	ND					
DE17	Würgassen/Beverung	Weser															
DK01	Risø	Kattegat through Roskilde Fjord															
ES02	José Cabrera	Tagus	1.41E-05								4.17E-04						
FR04	Chinon	Loire									5.60E-07						
FR05	Chooz	Meuse	3.27E-06		2.46E-07						2.94E-04						
FR15	La Hague	English Channel	4.14E-03		1.29E-03						3.00E-02				5.04E-03		
FR17	Fontenay-aux-Roses	Seine															
UK01	Berkeley	Severn									7.78E-06						
UK02	Bradwell	North Sea									Nil						
UK04	Chapelcross	Solway Firth															
UK05a	Dungeness A	English Channel									1.67E-02						
UK08a	Hinkley Point A	Severn									1.17E-04						
UK09a	Hunterston A	Firth of Clyde									1.88E-04				5.00E-05		
UK10	Oldbury	Severn Estuary									3.82E-02						
UK11a	Sizewell A	North Sea									1.09E-01						
UK13	Trawsfynydd	Trawsfynydd									2.30E-04						
UK15	Sellafield	Irish Sea	1.03E+00	3.75E-02	2.02E-01	2.05E-03			5.56E-02	1.98E-03	2.13E+00	2.30E-03	8.09E-03	6.25E-02	6.16E-01	1.42E-02	9.49E-06
UK18	Dounreay	Pentland Firth	3.90E-02								2.90E-03						
UK19	Harwell	River Thames									3.60E-06						
UK20	Winfrith	Weymouth Bay									4.32E-04						

3.3 Endnotes to data tables 4 to 8

Table 4

(1) The value indicated corresponds to the sum of individually assessed nuclides except tritium.

(2) ß-Activity for Tihange/Doel: Sr-89, Sr-90, Fe-55. Other radionuclides for Tihange/Doel: Cr-51, Mn54, Co-57, Fe-59, Ru-103, Te-123m, Sb-124, I-131, Ba-140, La-140, Ce-141.

(3) 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 2018, their net electrical output was 329 millions of MWh. (4)

(4) Data from the producers EDF.

(5) DE3 Brunsbüttel, DE8a Krümmel, DE16 Rodenkirchen/Unterweser No power operation since 2011

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

(7) Regarding the nuclear power plants, the discharge data have been estimated taking into account the criteria set out in Commission Recommendation 2004/2/EURATOM of 18 December 2003 on standardised information on radioactive airborne and liquid discharges into the environment from nuclear power reactors and reprocessing plants in normal operation.

(8) Other radionuclides for Almaraz: Cr-51, Mn-54, Fe-55, Fe-59, Co-58, Co-60, Ni-63, Zn-65, Sr-89, Sr-90, Nb-95, Zr-95, Ru-106, Ag-110m, Sb-122, Sb-124, Sb-125, Te-123m, I-131, Cs-134, Cs-137, . Other radionuclides for Trillo: Mn-54, Fe-55, Co-58, Co-60, Ni-63, Nb-95, Ag-110m, Cs-137. In both cases activities for Fe-55 and Ni-63 have been estimated from Co-60 using factors that have been obtained as a result of the analysis of annual compound samples.

(9) Total-α activity reported for Spanish NPP is actually a "Total-α" measurement.

(10a) The value reported corresponds to the sum of individually assessed α-emitting radionuclides

(10b) The value reported corresponds to the sum of individually assessed β-emitting radionuclides, excludning H-3 but including the other beta emitting nuclides in the table

(10c) The value reported corresponds to the sum of the detected radionuclides not mentioned in the table

(11) For Ringhals unit 1 the following radionuclides were detected: Cr-51, Mn-54, Co 58, Co-60, Ni-63, Zn-65, Zr-95, Nb-95, Ag-110m, Sb-124, Sb-125, Sr-90, Cs-137, H-3, Pu-238, Pu-239/Pu-240, Am-241, Cm-242, Cm-244

(12) For Ringhals unit 2 the following radionuclides were detected: Cr-51, Mn-54, Co-58, Co-60, Ni 63, Zr-95, Nb-95, Ag-110m, Sb-122, Sb-124, Sb-125, Sr-90, Te-123m, Cs-137, H-3, Pu-238, Pu-239/Pu-240, Am-241, Cm-242, Cm-244

(13) For Ringhals unit 3 the following radionuclides were detected: Cr-51, Mn-54, Co-58, Co 60, Ni-63, Zr-95, Ag-110m, Sb-124, Sb-125, Te-123m, Cs 137, H-3, Pu-238, Pu-239/Pu-240, Am-241, Cm-242, Cm-244

(14) For Ringhals unit 4 the following radionuclides were detected: Cr-51, Mn-54, Fe-59, Co 58, Co-60, Ni-63, Zr-95, Cs-137, Ag-110m, Sb-124, Sb-125, Te-123m, H-3, Pu-238, Pu-239/Pu-240, Am-241, Cm-242, Cm-244 (15) Total-B value is the sum of the radioactivity of individual radionuclides that do not belong to tritium and alpha emitters.

(16) Highest values of detection limit, among all the measurements below the detection limit, for Almaraz (Bq/m3) H-3: 2.36E+04, Co-60: 5.99E+03, Sr-90: 2.91E+02, Cs-137: 8.95E+03, Total-alpha: 8.95E+02. For Trillo (Bq/m3) H-3: 6.72E+04, Co-60: 2.59E+03, Sr-90: 9.50E+02, Cs-137: 3.51E+03, Total-alpha: 9.28E+02.

(17) NPP DE4 Grafenrheinfeld No power operation since 2015.

(xx) Oldbury (UK10) No power operation since 2012

(17) UK: Wylfa ceased energy production in December 2015

Table 5

(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) UK: 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 299 280 teU for 20172018. THORP reprocessing ended in November 2018.

Table 7

(1a) France informs that the line entitled "other radionuclides" corresponds to the sum “gamma emitters + strontium-90”

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

(2) Delft site refers to Research Reactor of Technical University Delft and different laboratories.

(3) The data represent the total emissions/discharges from the Reactor Institute Delft (RID) complex, including the Research Reactor (HOR) and different laboratories (it is not possible to make a distinction between the various sources). The discharges from the RID-HOR are substantially lower than the total values reported.

(4) "Total-β" value represents all β-emitting nuclides, including tritium.

(5) The data represent the total emissions/discharges from the Petten complex. This will lead to an overestimate of the discharges of the reactor (it is not possible to distinguish the discharges from the reactor). The LFR (“Low Flux Reactor”) is no longer in use since December 2010.

(6) Petten site refers to Research reactor of EU-JRC, the low-flux research reactor (no longer in use since December 2010), Hot Cell Laboratories, Mo Production Facilities and Decontamination and Waste Treatment of NRG.

(7) "Total-β" value represents an assimilation of β-emitting and γ-emitting radionuclides.

(8) Some radionuclides reported to be discharged in small amounts by IFE are not included as specific nuclides in the spreadsheet.

From IFE Halden, these radionuclides are: Zr-97, Ru-103, Sb-124, La-140

All these have been included in the Total-β.

From IFE Kjeller, these radionuclides are: Ba-133, U-234, U-238, Cm-244

Ba-133 have been included in the Total-β, rest have been included in the Total-α.

Both IFE Halden and IFE Kjeller is no longer in operation, and will be decommissioned.

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

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

Detection limit

Halden

Radionuclide	Highest DL [Bq/m3]
H3	300000
Cr51	1500
Mn54	95
Co58	200
Co60	110
Sr90	1
Nb95	1250
Zr95	180
Zr97	14300
Ru103	130
Cd109	430
Ag110m	75
Sb124	35
Sb125	31200
I131	240
Cs134	100
Cs137	300
La140	80
Ce141	40
Ce144	250

Kjeller

Radionuclide	**Highest DL [Bq/m3]**
H3	2000000
Na22	1100
Cr51	4000
Mn54	900
Fe59	1300
Co58	1100
Co60	1300
Zn65	1600
Sr90	50
Zr95	700
Nb95	500
Ru103	400
Ru106	10000
Ag110m	3000
Sb124	2300
Sb125	1000
I125	6000
I131	40
Cs134	2600
Cs137	1900
Ba133	4000
Ce144	8000
Ra223	600
Th227	1200
U234	6
U235	5
U238	6
Pu238	60
Pu239	40
Pu240	40
Am241	2,5
Cm243	2,7
Cm244	2,7

(11) Shut down in 2006

(12) Shut down in 2010

Table 8

(1) The value indicated corresponds to the sum of individually assessed nuclides except tritium.

(2) Additionally reporting required at discharges of H-3 above 2 TBq in one month.

Additionally reporting required at discharges of Gross-β above 0,3E-03 TBq in one month.

(3) DK: 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.

(4) FR: The column entitled "other radionuclides" corresponds to the sum "PF+PA+C14+Ni63+Fe55+Sr90+Tc99".

(5) DE: Lingen shut down in 1977.

(6) SE: Shut down in 1986.

(7) DE: Obrigheim shut down in 2005.

(8) DE: Rheinsberg shut down in 1990.

(9) DE: Stade shut down in 2003. No discharges in 2018

(10) SE: Shut down in 1994.

(11) ES: Other radionuclides for José Cabrera: Fe-55, Co-60, Ni-63, Sr-90, Cs-137. Activities for Fe-55 and Ni-63 have been estimated from Co-60 using factors that have been obtained as a result of the analysis of annual compound samples.

(12) CH: 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 is 2005. Since 2010 only operational waste from the nuclear power stations and the research and development facility Paul Scherrer Institute is treated.

(13) UK: Trawsfynndd (UK13) Electricity generation ceased in 1991. De-fuelling was completed in 1995. Decommissioning is still in progress.

(13a) UK: Berkeley (UK 01) Electricity generation started in 1962 and ceased in 1989. De-fuelling was completed in 1962. Decommissioning is still in progress.

(13b) UK: Bradwell (UK02) Ceased electricity production in 2002. De-fuelling was completed in 2006.The site followed an accelerated decommissioning programme which is now complete. Final site clearance is planned to commence in 2083 and achieved by 2092.

(13c) UK: Chapelcross (UK03) Ceased electricity generation in 2004. De-fuelling began in 2008 and was completed in 2013. Decommissioning is still in progress.

(13d) UK: Dungeness (UK04) Ceased electricity generation in 2006. De-fuelling was completed in 2012.

(13e) UK: Hinkley Point A (UK08a) Electricity generation started in 1965 and ceased in 2000. De-fuelling was completed in 2004. Decommissioining is still in progress.

(13f) UK: Hunterston (UK09a) Ceased electricity generation in 1990. De-fuelling was completed in 1995. Decommissioning is still in progress.

(13g) UK: Oldbury (UK 10) Electricity generation started in 1967 and ceased in 2012. De-fuelling was completed in 2016.

(13h) UK: Sizewell A (UK11a) Ceased electricity generation in 2006. De-fuelling commenced in 2007 and was completed in 2014.

(13i) UK: Dounreay (UK18) The research reactors are closed and undergoing decommissioning.

(13j) UK: Harwell (UK19) The research reactors are either completely removed, or those remaining are de-fuelled. Decommissioning is well underway.

(13k) UK: Winfrith (UK20) The research reactors are either decommissioned and dismantled, or those remaining are expected to be decommissioned by 2023.

(14) UK: Total Beta is calculated in the same way as in Table 5

(14a) UK: In 2018 the main operations were: fuel processing at the Magnox Reprocessing Plant and the Thermal Oxide Reprocessing Plant (THORP); decommissioning and clean up of redundant nuclear facilities; and waste treatment and storage.

(15) ES: Highest values of detection limit, among all the measurements below the detection limit, for José Cabrera (Bq/m3) Sr-90: 1.80E+02. The other key radionuclide measurements have always been above the detection limit.

(16) DE: Biblis A shutdown 2011

(17) DE: Biblis B shutdown 2011

(18) DE: Brunsbüttel shutdown 2011

(19) DE: Grafenrheinfeld shutdown 2015

(20) DE: Krümmel/Geesthacht shutdown 2011

(21) DE: Mülheim-Kärlich shutdown in 1988

(22) DE: Neckar-Westheim 1 shutdown 2011

(23) DE: Philippsburg 1 shutdown 2011

(24) DE: Rodenkirchen/Unterweser shutdown 2011

(25) DE: Würgassen/Beverungen shutdown 1994, fully decommissened 2017

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