OSPAR
COMMISSION

Sixth Implementation Report:

Report in accordance with PARCOM Recommendation 91/4 on radioactive discharges

France

Radioactive Substances Series

2014

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

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EXECUTIVE SUMMARY

The control of nuclear safety and radiation protection in France has been completely revised since 2006. The 13th June 2006 Act concerning transparency and security in the nuclear field, called the "TSN Act" (now codified in books I and V of the Environment Code), extensively overhauled the BNI legal system. It has in particular given this system an "integrated" nature, that is to say that it seeks to prevent the hazards and detrimental effects of any type that the BNIs could create: accidents - whether nuclear or not, pollution - whether radioactive or not, waste – whether radioactive or not, noise, etc.

Decree 2007-1557 of 2nd November 2007 as amended concerning BNIs and regulation of the nuclear safety of the transport of radioactive substances, known as the "BNI Procedures" decree, defines the framework in which the BNI procedures are carried out and covers the entire lifecycle of a BNI, from its authorization decree to commissioning, to final shutdown and decommissioning.

These foundation texts have been recently supplemented by the Order of 7th February 2012 setting the general rules relative to basic nuclear installations, called the "BNI" order, and ASN (French nuclear safety authority) resolution 2013-DC-360 of 16th July 2013 relating to the control of detrimental effects and of the impact on health and the environment of BN.

France has fully incorporated the best available techniques (BAT) into its legislative and regulatory texts. The best available techniques appear in the front rank of the principles that control nuclear activities in France.

Even if the radiologic impact associated with liquid radioactive discharges is very low, France is determined that its regulatory framework and operator practices will led, through the application of the best available techniques, to achieve a high level of control over radioactive discharges and to obtain reductions in discharges, in line with the OSPAR strategy. France will ensure that this approach is applied in a fully transparent manner, and will involve the various stakeholders. Although that in general effluents discharges decrease, France considers that the reduction of radioactive discharges continues in line with technical progress. This is achieved by proceeding with the overhaul of the discharges permits of the basic nuclear installations. France requires that the limits be set as low as the best available techniques will allow, taking into account feedback from experience with the discharges produced at the facilities.

France has set up a system for monitoring environmental radioactivity that meets the objectives of the OSPAR strategy both in terms of coverage of the French portion of the OSPAR area, and of the quality of the monitoring data provided under the agreement concerning the program for monitoring radioactive substances in the marine environment.

Application of the BAT (Best Available techniques) to the AREVA NC LA HAGUE facilities.

The methods selected by the operator to minimise the radioactive discharges and emissions from the AREVA NC La Hague site are based upon a continuous approach. The foundations of this one are the technical and economic evaluation of the new solutions offered by research developments, for both processes and technology. The management methods for liquid discharges have been reviewed, with the introduction inter alia of the "new effluent management", which is based on using evaporators that concentrate radioactivity sent to vitrification and purify the distillate that is either recycled into the process or discharged practically free of radioactivity.

The records of the period confirm the validity of the arrangements implemented, such as:

- The replacement of UP2-400 units by more sophisticated and modern facilities (R4 being the last example), with the replacement of pulsed columns or mixers-settlers by centrifugal extractors that induces a lower degradation of the solvent, resulting in a lesser volume of effluent.

- The complete implementation of the NGE (New effluent management) that sorts aqueous effluents in function of their acidity before evaporating them.
- The continuous purification of solvent and diluent in the TEO (Organic Effluent Treatment) units by distillation under vacuum.
- The discharges to the sea are still lowering as well as the impact on the representative person that is at a very low level.

Extensive R&D is ongoing to investigate more improvements in many fields, but though the considerable resources involved, the potential for improvement is lowering and no new process emerges to set a new standard as Best Available Technique.

The same methods and processes as well as the same equipment are used for the reduction of the discharges resulting from exceptional operations such as dismantling and reconditioning of legacy waste. Those that have been undertaken during the period have thus generated visible but very low radioactive discharges.

These accomplishments show how the best techniques are continuously developed and used on the AREVA NC La Hague plants to improve the process and the abatement techniques as soon as they become available, with reductions in the volume and the activity of the effluents as well as in the corresponding impact that bring them at a level such that that the objective of an industrial activity to perform without any harm neither to the workers nor to the population can be considered as reached.

Application of the BAT (Best available techniques) to the French Nuclear Power Plants (EDF)

In addition, EDF has continued its efforts on operating practices to allow lowering radioactive discharges. These actions have resulted in a significant reduction in the discharges of activity by liquid effluents for all categories of radionuclides (excepted tritium and carbon 14) in the last 20 years. Among these practices, it can be noted a better selection of effluents at the source so that they can be sent for appropriate treatment, the increase in the treatment of effluents by evaporation and optimisation of effluents recycling.

As regards tritium, there is still no industrial method for trapping it (given the large volumes of water to be processed and the corresponding low activity). Tritium in NPPs' discharges is still a subject for R&D. For example EDF is currently working on tritium speciation in liquid discharges, and standardisation of tritium (and carbon14) measurement techniques in liquid (and also gaseous) discharges.

Finally, EDF has extended to all its NPPs the implementation in environmental monitoring of BAT in the measurements of tritium and carbon 14.

Application of the BAT (Best available techniques) to the radioactive discharges of the CEA centres (French Alternative Energies and Atomic Energy Commission).

Even if the CEA's discharges cannot be detectable in the marine environment, due to the distance and to the fact they have been already diluted before arriving in the Seine, France is very attentive to the application of the BAT to deal with these discharges.

The programme of denuclearisation of the centre of Fontenay-aux-Roses, which is currently in progress, will include the cleanup and complete dismantling of the nuclear installations. This process will be accompanied by ever smaller liquid discharges. Since the start of the 1990s, there has been a net reduction in liquid discharges of the centre of Saclay, which varies from a factor 5 to 30 depending on the radionuclide or groups of radionuclides considered.

Radioactive liquid discharges to the environment have very low radiological activity and their characteristics are within authorized limits. Prior to the discharge, this effluent is treated to reduce its radioactivity. The most active liquid waste from the installations is always in dedicated tanks specific to its nature and activity. It is then transferred towards one of three treatment stations of the CEA. Its subsequent treatment in a dedicated treatment plant concentrates a large part of radioactive material into solid waste.

In the centre of Saclay, the radioactive liquid effluent treatment installation has benefited from a major renovation program which will permit the treatment of approximately 1500 m3 of effluent per year. This installation benefits from best available technologies. It is equipped on one hand with a new evaporator benefiting from the last technical progress and from the acquired experience and on the other hand from the new process of solidification of the evaporation concentrates by concreting to guarantee a better safety towards the risk sets on fire. The factors of decontamination of the radioactive effluents already high with the current installation will be still improved (more than 10,000 for the main alpha, beta or gamma radionuclide emitters, except the tritium and the carbon 14).

The remainder whose activity is within authorized limits can be ultimately discharged to the environment; a number of tests are performed before during and after the discharge. The continuous improvement of the performance of the installations and processes has permitted the reduction of discharges to the environment over a number of years.

The exposure to annual liquid discharges for the reference group of every site is estimated for several scenarios every year and ends in very low doses locally, and would be ever less when reaching the English Channel.

INTRODUCTION

1. Purpose of the Report

This report is submitted as part of an examination of the implementation of PARCOM Recommendation 91/4 on radioactive discharges, concerning which the contracting parties agreed: *"To respect the relevant Recommendations of international organizations and to apply the Best Available Technology to minimize and, as appropriate, eliminate any pollution caused by radioactive discharge from all nuclear industries, including research reactors and reprocessing plants, into the marine environment."*

According to Appendix 1 of the OSPAR Convention, for the purposes of OSPAR the best available techniques are defined as follows:

BEST AVAILABLE TECHNIQUES

1. In seeking the best available techniques, emphasis is placed on the use of technologies that do not produce wastes, if such are available.

2. The expression "best available techniques" means the very latest advances (state of the art) in processes, facilities, or methods of operation, that enable a decision as to whether a given constraining measure for discharges, emissions, or wastes is appropriate form a practical standpoint. To determine whether a series of processes, facilities, and methods of operation represents the best available techniques in general or in a specific case, special attention is given:

   (a) To comparable processes, facilities, or methods that have given good results in recent trials;

   (b) To technical advances and the development of scientific knowledge and understanding;

   (c) To the economic feasibility of these techniques;

   (d) To the time it would take to put them into operation, both in new facilities and in existing ones;

   (e) To the nature and volume of the discharges and emissions in question.

3. It therefore follows that what constitutes "the best available technique" for a given process will change over time, depending on technical advances, economic and social factors, and the development of scientific knowledge and understanding.

4. If the reduction in discharges and emissions that results from the application of the best available techniques does not lead to acceptable results on the environmental level, additional measures must be implemented.

5. The term "techniques" means not only the technique applied but also the facility's method of design, construction, maintenance, operation, and dismantling.

The control of nuclear safety and radiation protection in France has been completely revised since 2006. The 13th June 2006 Act concerning transparency and security in the nuclear field, called the "TSN Act" (now codified in books I and V of the Environment Code), extensively overhauled the BNI legal system. It has in particular given this system an "integrated" nature, that is to say that it seeks to prevent the hazards and detrimental effects of any type that the BNIs could create: accidents - whether nuclear or not, pollution - whether radioactive or not, waste – whether radioactive or not, noise, etc.

Decree 2007-1557 of 2nd November 2007 as amended concerning BNIs and regulation of the nuclear safety of the transport of radioactive substances, known as the "BNI Procedures" decree, defines the framework in which the BNI procedures are carried out and covers the entire lifecycle of a BNI, from its authorization decree to commissioning, to final shutdown and decommissioning.

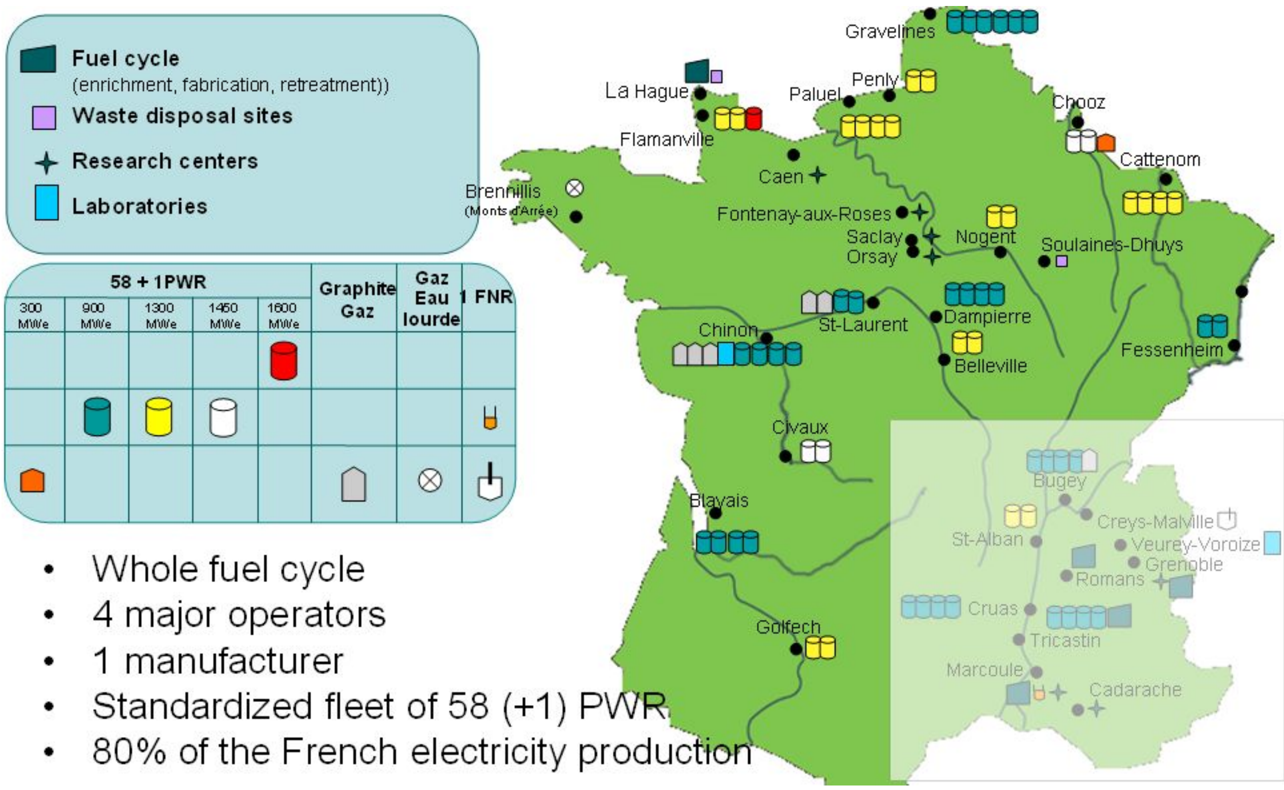
These foundation texts have been recently supplemented by the Order of 7th February 2012 setting the general rules relative to basic nuclear installations, called the "BNI" order, and ASN (French nuclear safety authority) resolution 2013-DC-360 of 16th July 2013 relating to the control of detrimental effects and of the impact on health and the environment of BN.

Therefore, this report applies to a situation in which the regulatory framework applicable to BNIs has been significantly reinforced.

2. French facilities in the OSPAR area

As of January 1, 2013, France had 125 basic nuclear installations, distributed over about forty sites. These include the following facilities discharging radionuclides within the OSPAR area:

- The La Hague spent fuel reprocessing plant;
- 15 nuclear power stations on 19 sites, thus including 44 of the 58 operating pressurized-water reactors in France;
- The research and development centres at Fontenay-aux-Roses and Saclay.



French nuclear facilities

(The facilities in dimmed part do not discharge into the OSPAR area)

PART I – GENERAL INFORMATION

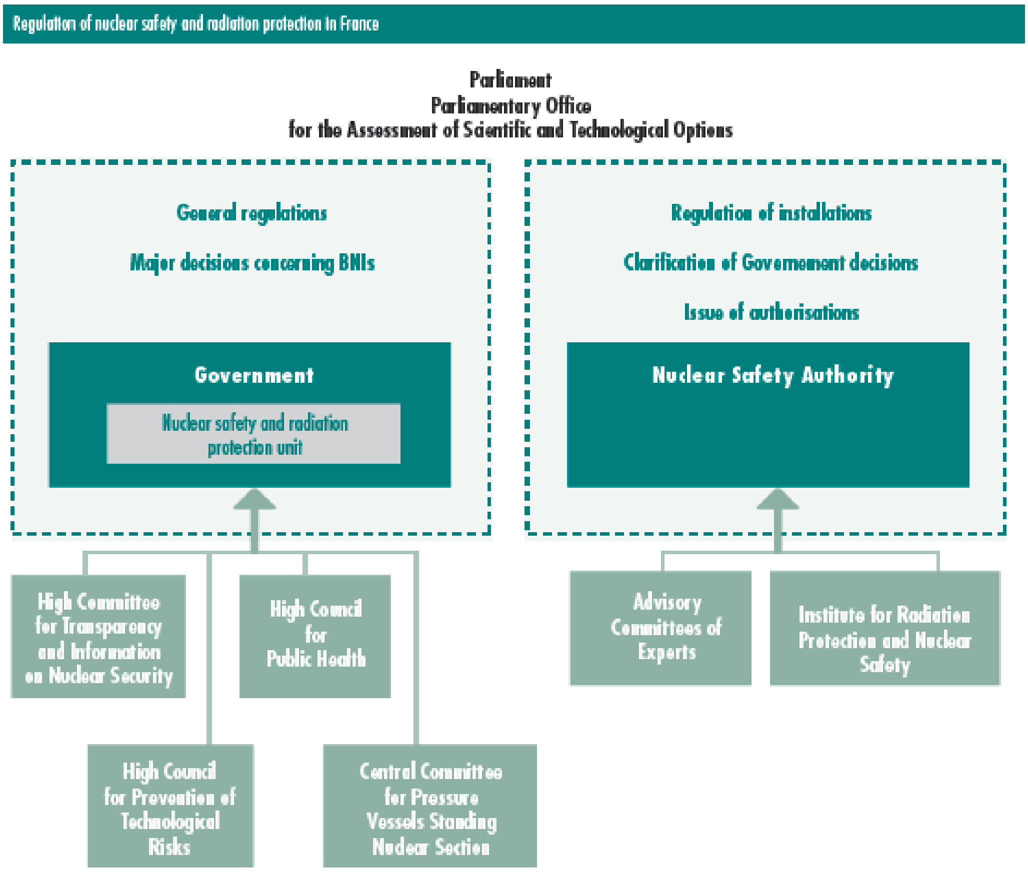
1. The organization of nuclear safety and radiation protection control in France

Law No. 2006-686 of June 13, 2006 concerning transparency and nuclear safety, known as the "TSN" law and now codified in the Environment Code, caused a comprehensive reform of the organization of nuclear safety and radiation protection control in France. It relies on a variety of actors: State structures, forums for information and debate, and technical support organizations.

1.1. State structures

The control of nuclear safety and radiation protection involves all of the State's structures:

- The Parliament, to define the major long-term options;
- The Government, especially the ministers responsible for nuclear safety and radiation protection, who have been assigned the power for overall regulation and for matters concerning the desirability of creating a basic nuclear installation;
- The prefects, responsible for protecting the population;
- Advisory authorities, which provide an outside view on significant decisions regarding nuclear safety and radiation protection;
- The Nuclear Safety Authority (ASN), which is the control and regulation authority;



The organization of nuclear safety and radiation protection control in France

1.1.1. The Parliament

The Parliament's principal role in the field of nuclear safety and radiation protection is to make laws. Two major Acts were passed in 2006: the above-mentioned TSN Act of 13th June 2006, on transparency and security in the nuclear field; and the Programme Act of 28th June 2006, on the sustainable management of radioactive materials and waste.

The Parliament's decisions were clarified by the Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST), whose mission is to inform the Parliament about the consequences of choices of a scientific and technologic nature - which include nuclear safety and radiation protection matters. For this purpose it gathers information, implements research programs, and conducts evaluations. Its work is available on the OPECST's website (http://www.senat.fr/opecst/).

1.1.2. The Government

The Government exercises regulatory powers. It is therefore in charge of laying down the general regulations concerning nuclear safety and radiation protection. The TSN Act also tasks it with making major decisions concerning BNIs, for which it relies on proposals or opinions from ASN. The Government can also call on consultative bodies such as the High Committee for Transparency and Information on Nuclear Safety (HCTISN).

The Government is responsible for civil protection in the event of an emergency.

1.1.3. Ministers responsible for nuclear safety and radiation protection

On the advice of ASN and, as applicable, on the basis of an ASN proposal, the Minister(s) responsible for nuclear safety define(s) the general regulations applicable to BNIs and take the major individual decisions concerning:

- the design, construction, operation, final shutdown and decommissioning of BNIs;
- the final shutdown, maintenance and surveillance of radioactive waste disposal facilities;
- the manufacturing and the operation of pressure equipment (PE) specifically designed for these installations.

The above-mentioned minister(s) can suspend the operation of an installation on the advice of ASN if it presents serious risks.

Furthermore, the Minister(s) responsible for radiation protection also define(s) - on the basis of ASN proposals if necessary – the general regulations applicable to radiation protection.

The regulation of worker radiation protection is the responsibility of the Minister for labour.

Finally, the Ministers responsible for nuclear safety and for radiation protection approve the ASN internal regulations by means of a Government order. Each of them also approves ASN technical regulatory resolution and certain individual resolution (setting BNI discharge limits, delicensing a BNI, etc.) affecting their own particular field.

The MSNR (Nuclear Safety and Radiation Protection Mission), within the General Directorate for Risk Prevention at the Ministry of Ecology, Sustainable Development and Energy, is tasked - in collaboration with ASN - with proposing Government policy on nuclear safety and radiation protection, except for defence-related activities and installations and the radiation protection of workers against ionising radiations.

1.1.4. High Committee for Transparency and Information on Nuclear Safety

The TSN Act created a High Committee for Transparency and Information on Nuclear Security (HCTISN), an information, discussion and debating body dealing with the risks inherent in nuclear activities and the impact of these activities on human health, the environment and nuclear safety.

The High Committee can issue an opinion on any question in these fields, as well as on controls and the relevant information. It can also deal with any issue concerning the accessibility of nuclear safety information and propose any measures such as to guarantee or improve nuclear transparency. It can be called on by the Government, Parliament, the local information committees or the licensees of nuclear facilities, with regard to all questions relating to information about nuclear safety and its regulation and monitoring.

All of this work is available on its website: http://www.hctisn.fr.

1.1.5. Prefects

The Prefects are the State's representatives in the *départements*[1]. They are the guarantors of public order and play a particularly important role in the event of an emergency, in that they are responsible for measures to protect the general public. The Prefect in particular issues his opinion on authorisation applications and, at the request of ASN, calls on the Departmental Council for the Environment and Health and Technological Risks, to obtain its opinion on water intake, effluent discharges and other detrimental effects of BNIs.

1.1.6. Nuclear Safety Authority (ASN)

The TSN Act created an independent administrative nuclear safety authority (ASN) to monitor and regulate nuclear safety and radiation protection. ASN's remit comprises regulation, authorisation and monitoring as well as providing support to the public authorities for management of emergencies and contributing to informing the general public.

ASN is made up of a commission and of various departments.

From a technical point of view, ASN relies on the expertise with which it is provided, notably by IRSN and by Advisory Committees of Experts (GPEs).

ASN is consulted on draft decrees and ministerial orders of a regulatory nature and dealing with nuclear safety. It can take regulatory resolutions of a technical nature to complete the implementing procedures for decrees and orders adopted in the nuclear safety or radiation protection field, except for those relating to occupational medicine. These resolutions are subject to approval by the Ministers responsible for nuclear safety and for radiation protection.

ASN reviews BNI authorisation or decommissioning applications, issues opinions and makes proposals to the Government concerning the decrees to be issued in these fields. It defines the requirements applicable to these installations with regard to the prevention of risks, pollution and detrimental effects. It authorises commissioning of these installations and pronounces delicensing following completion of decommissioning. Some of these ASN resolutions require approval by the Ministers responsible for nuclear safety.

ASN also issues the licenses provided for in the Public Health Code (CSP) concerning small-scale nuclear activities and issues authorisations or approvals for radioactive substance transport operations.

ASN's resolutions and opinions are published in its Official Bulletin on its website (www.asn.fr).

ASN checks compliance with the general rules and specific requirements concerning nuclear safety and radiation protection applicable to nuclear activities.

ASN organises permanent radiation protection monitoring throughout the national territory.

[1] Administrative region headed by a Prefect

From among its own staff, it appoints nuclear safety inspectors, radiation protection inspectors and officers in charge of verifying compliance with pressure equipment requirements. It issues the required approvals to the organisations participating in the verifications and nuclear safety or radiation protection monitoring.

ASN takes part in managing radiological emergency situations. It provides technical assistance to the competent authorities for the drafting of emergency response plans, taking account of the risks resulting from nuclear activities.

When such an emergency situation occurs, ASN verifies the steps taken by the licensee to make the facility safe. It assists the Government with all matters within its field of competence and submits its recommendations on the medical or health measures or civil protection steps to be taken. It informs the general public of the situation, of any releases into the environment and their consequences. It acts as the competent authority within the framework of international conventions, by notifying international organisations and foreign countries of the accident.

ASN participates in informing the public in its areas of competence.

1.2. Technical support organizations

Created by Act 2001-398 of 9th May 2001 and by decree 2002-254 of 22nd February 2002, Institute for Radiation Protection and Nuclear Safety (IRSN) was set up as an independent public industrial and commercial establishment, as part of the national reorganisation of nuclear safety and radiation protection regulation, in order to bring together public expertise and research resources in these fields. IRSN reports to the ministers for the environment, health, research, industry and defence.

IRSN conducts and implements research programmes in order to build its public expertise capacity on the very latest national and international scientific knowledge in the fields of nuclear and radiological risks. It is tasked with providing technical support for the public authorities with competence for safety, radiation protection and security, in both the civil and defence sectors.

IRSN also has certain public service responsibilities, in particular monitoring of the environment and of populations exposed to ionising radiation.

IRSN manages national databases (national nuclear material accounting, national inventory of radioactive sources, file for monitoring worker exposure to ionising radiation, etc.), and contributes to informing the public about the risks associated with ionising radiation.

On the technical level the ASN relies on the expertise provided by the Institute of Radiological Protection and Nuclear Safety (IRSN) and Standing Expert Groups (GPE).

1.2.1. Standing Expert Groups (GPE)

In preparing its decisions, ASN calls on the opinions and recommendations of seven Advisory Committees of Experts (GPE), with expert knowledge in the areas of waste, nuclear pressure equipment, medical exposure, non-medical radiation protection, reactors, transport, and laboratories and nuclear plants.

ASN consults the GPEs in preparing its main decisions. In particular, they review the preliminary, provisional and final safety analysis reports for each BNI. They can also be consulted about changes in regulations or doctrine.

For each of the subjects covered, the GPEs examine the reports produced by IRSN, by a special working group or by one of the ASN departments. They issue an opinion backed up by recommendations.

The GPEs comprise experts nominated for their individual competence. They come from various backgrounds; universities, associations, appraisal and research organisations.

They can also be licensees of nuclear facilities or come from other sectors (industrial, medical, etc.). Participation by foreign experts can help diversify the approach to problems and take advantage of experience acquired internationally.

Since 2009, as part of its commitment to transparency in nuclear safety and radiation protection, ASN has published the GPE letters of referral, the opinions of the GPEs and ASN's position statements based on these opinions. IRSN for its part publishes the syntheses of the technical investigation reports it presents to the GPEs.

2. The legislative and regulatory framework for applying the best techniques available in France

2.1. *The legal system applicable to basic nuclear installations (BNIs)*

The legal system applicable to the BNIs was revised in depth by the Act 2006-686 of 13th June 2006 on transparency and security in the nuclear field, called the "TSN" Act, and its application decrees, and in particular decree 2007-1557 of 2nd November 2007 as amended, concerning BNIs and the regulation of the nuclear safety in the transport of radioactive substances, called the "BNI Procedures" decree.

Since 6th January 2012, the provisions of the three main acts that specifically concern the BNIs, namely the "TSN" Act 2006-686 of 13th June 2006 on transparency and security in the nuclear field, the Programme Act 2006-739 of 28th June 2006 relative to the sustainable management of radioactive materials and waste (called the "Waste" Act), and Act 68-943 of 30th October 1968 relative to civil responsibility in the field of nuclear energy (called the "RCN" Act) – are now codified in the Environment Code.

The regulatory provisions in effect (particularly those of the "BNI procedures" decree of 2nd November 2007) will be also codified into the Environment Code.

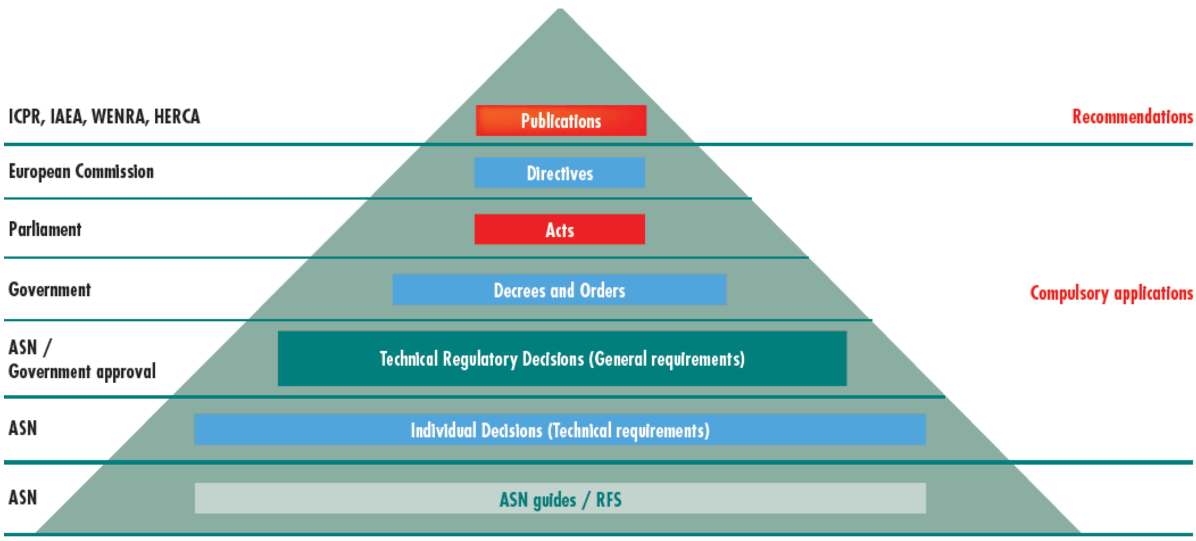
2.1.1. Environment Code

The provisions of chapters III and V of part IX of book V of the Environment Code underpin the BNI licensing and regulation system.

The legal system applicable to BNIs is said to be "integrated" because it aims to cover the prevention or control of all the risks and detrimental effects, whether radioactive or not, that a BNI could create for man and the environment.

About fifteen decrees implement the legislative provisions of book V of the Environment Code, in particular decree 2007-830 of 11th May 2007 concerning the list of BNIs and decree 2007- 1557 of 2nd November 2007 as amended, concerning BNIs and the regulation of the nuclear safety of the transport of radioactive substances, known as the "BNI Procedures" decree (see below).

The provisions of chapter II of part IV of book V of the Environment Code (drawn in particular from the codification of the "Waste" Law) introduce a coherent and exhaustive legislative framework for the management of all radioactive waste.



Various levels of regulation in the field nuclear activities in France (orientations, recommendations): legally binding or non-binding nature

2.1.2. "BNI Procedures" decree of 2nd November 2007

Decree 2007-1557 of 2nd November 2007 as amended concerning BNIs and regulation of the nuclear safety of the transport of radioactive substances, known as the "BNI Procedures" decree, implements Article L. 593-38 of the Environment Code. It defines the framework in which the BNI procedures are carried out and covers the entire lifecycle of a BNI, from its authorization decree to commissioning, to final shutdown and decommissioning. Finally, it explains the relations between the minister responsible for nuclear safety and ASN in the field of BNI safety.

The decree clarifies the applicable procedures for adoption of the general regulations and for taking individual decisions concerning BNIs. It defines how the Act is implemented with regard to inspections and administrative or criminal sanctions.

Finally, it defines the particular conditions for application of certain regimes within the perimeter of the BNIs.

Further to the codification of the "TSN" Act of 13th June 2006, this decree, like all the other implementing decrees of this Act, should be codified in the regulatory part of the Environment Code.

2.1.3. Order of 7th February 2012 and ASN resolution 2013-DC-360 of 16th of July 2013

The order of 7th February 2012 setting the general rules relative to basic nuclear installations, called the "BNI" order, significantly reinforces the regulatory framework applicable to BNIs, as it details a large number of requirements and provides a legal basis for several of the requirements expressed by ASN further to the analysis of the stress tests demanded of the licensees following the Fukushima accident.

The majority of the provisions of the "BNI" order, which was published in the Official Journal of 8th February 2012, came into force on 1st July 2013, on which date the following orders taken under the former regulation were repealed:

- the order of 10th August 1984 concerning the quality of design, construction and operation of BNIs, called the "Quality" order;
- the order of 26th November 1999 stipulating the general technical requirements concerning the limits and procedures applicable to BNI water intake and discharges requiring licensing.
- the order of 31st December 1999 stipulating the general technical regulations designed to prevent and mitigate the harmful effects and external hazards resulting from operation of BNIs.

The "BNI" order of 7th February 2012 addresses the following main subjects: organization and responsibility of BNIs, demonstration of nuclear safety, control of detrimental effects and of the impact on health and the environment, waste management, emergency situation preparedness and management.

The control of detrimental effects and of the impact on health and the environment part (4th part of the order) takes up and supplements the provisions of the orders of 26th November 1999 and 31st December 1999. This part was complemented by the ASN resolution 2013-DC-360 of 16th July 2013 relating to the control of detrimental effects and of the impact on health and the environment of BNIs. This resolution was approved by the Government by the order of the 9th August 2013 which was published in the Official Journal of 21st August 2013,

The "BNI" order of 7th February 2012 and the ASN resolution 2013-DC-360 of 16th July 2013 govern water intakes and effluent discharges, monitoring of the said intakes and discharges and of the environment, the prevention of pollution and detrimental effects, and the conditions of informing the authorities. The main new provisions are:

- use of the best techniques available within the meaning of the installation classified on environmental protection ground (ICPE regulation);
- setting up of monitoring of emissions and the environment;
- limiting of discharges and noise emissions to the thresholds;
- the application, in general, of a number of ICPE ministerial orders to the equipment necessary for BNI operation;
- the production of an annual discharge forecast and an annual impact report by the licensee.

2.2. Best available techniques BAT

France has fully incorporated the best available techniques (BAT) into its legislative and regulatory texts and has the tools to control their application in the various stages of live of its facilities.

The best available techniques constitute one of the pillars that underpin the requirements regarding protection of the environment and sustainable development. In this regard, the best available techniques are introduced at the highest level of French legal texts, which provide, through the Environmental Code, that actions for the protection, development, restoration, rehabilitation, and management of the environmental heritage must comply with the principle of preventive and corrective action, preferably at the source, against attacks on the environment, by using the best techniques available.

This requirement is imposed along with the following three other major principles:

- The precautionary principle, according to which a lack of certainty, in light of current scientific and technical knowledge, should not delay the taking of measured and effective steps aimed at preventing a risk of serious and irreversible damage to the environment, at an economically acceptable cost;
- The polluter-pays principle, under which the costs resulting from measures to prevent or reduce pollution and to combat it should be borne by the polluter;
- The participatory principle, according to which everyone has access to information about the environment, including information about hazardous substances and activities, and the public is involved in the process of developing projects having a significant effect on the environment or on land-use planning.

These principles are included in The Environmental Charter which is a constitutional text, built in the 2004 block of constitutionality of French law, recognizing the fundamental rights and duties related to environmental protection.

The TSN Law provides that the best available techniques, along with the other major principles in the area of environmental protection apply to nuclear activities. It also reaffirms the major principles in the area of radiation protection. It sets out the fundamental principle of the primary responsibility of the operator as regards the safety of its facility, written into international law, to be applied every day, and essential in order that each person, both operator and controlling authority, have a clear understanding of their responsibilities.

Accordingly, the best available techniques appear in the front rank of the principles that control nuclear activities in France.

The best available techniques are imposed in the order of 7th February 2012 and ASN resolution 2013-DC-360 of 16th of July 2013 establishing the general technical requirements concerning the limits and methods of withdrawals and discharges subject to permitting that are carried out by basic nuclear installations. In particular, this order requires that the limits for discharges must be established on the basis of the best available techniques (article 4.1.2).

In BNIs regulation, the best available techniques are to be understood in the sense of the Directive on industrial emissions 2010/75/EU (IED) thereby fully encompassing the definition given in the OSPAR Convention:

"best available techniques" means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole:

(a) "techniques" includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;

(b) "available techniques" means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator;

(c) "best" means most effective in achieving a high general level of protection of the environment as a whole;

Appendix III: Criteria for determining best available techniques

1. the use of low-waste technology;

2. the use of less hazardous substances;

3. the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate;

4. comparable processes, facilities or methods of operation which have been tried with success on an industrial scale;

5. technological advances and changes in scientific knowledge and understanding;

6. the nature, effects and volume of the emissions concerned;

7. the commissioning dates for new or existing installations;

8. the length of time needed to introduce the best available technique;

9. the consumption and nature of raw materials (including water) used in the process and energy efficiency;

10. the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it;

11. the need to prevent accidents and to minimise the consequences for the environment;

12. information published by public international organisations.

3. Radioactive discharges from nuclear facilities

In France there is very little radiologic impact from radioactive discharges produced by the nuclear industry, medical activities, or other industrial and research activities.

Nevertheless, although effluent discharges are broadly declining, France believes it is necessary in light of the objectives set by the OSPAR strategy to continue to reduce radioactive discharges in France, in line with technical advances. It contributes to these goals by setting limits for discharges and by requiring operators to use the best available techniques, while providing a fully transparent control process.

The ASN checks that the operators fulfil their responsibilities, starting with the design of the facility and continuing throughout its operation. It is vigilant concerning the optimization of discharges and the reduction of their impact.

3.1. Permitting of discharges from BNIs

3.1.1. The new BNI system

The TSN Law creates an integrated system based on a broadened conception of nuclear safety, covering both the prevention of accidents and the protection of human health and of the environment. It defines the conditions for the issuance of a permit to build or to dismantle a BNI, giving measures concerning prevention and limits the importance they deserve. In particular, it recognizes the fact that in this area as in all others risk cannot be completely eliminated, and that the measures adopted are aimed at preventing or limiting the risks, in light of current scientific knowledge and techniques.

The BNI permitting and control system is governed by Decree No. 2007-1557 of November 2, 2007 concerning basic nuclear installations and the control, as regards nuclear safety, of the transport of radioactive substances (see point 2.1).

The system provides that permits for the construction, final shutdown, and dismantling of basic nuclear installations, which are issued as decrees, incorporate all of the issues, whether they concern nuclear safety, radiation protection, or protection of the environment, using an integrated approach. These authorizing decrees will therefore include the authorization of discharges from the BNI.

These authorizing decrees are supplemented by individual stipulations based on ASN resolutions which set out in particular, where needed, the requirements regarding withdrawals of water by the BNI and the discharge of radioactive effluents produced by the BNI. The specific stipulations setting the limits for discharges from the BNI into the environment are subject to ratification by the ministers responsible for nuclear safety.

The integrated approach required by this new system also applies to changes in the facilities and to reassessments of the facilities' safety. For these reassessments, Article 29 of the TSN Law stipulates that "the operator of a nuclear installation must periodically undertake a reassessment of the safety of its installation, in light of the best international practices". In addition, the TSN Law provides that safety reassessments take place every ten years, subject to an exemption provided in the authorizing decree and justified by the particular features of the installation. Implementation of the new BNI system enables problems related to effluent discharges to be considered during safety reassessments.

For existing facilities, ASN resolution 2013-DC-360 of 16th of July 2013 requires that operators must periodically conduct a performance analysis of prevention and reduction of impacts caused by the nuclear facility in relation to the effectiveness of best available techniques including assessing performance differences. In case of discrepancy, operators perform a techno-economic study to improve the performance obtained by the implementation of these best techniques. When the best available techniques allow a significant reduction of the impacts they are implemented by the operator if it’s technically and economically feasible.

3.1.2. Setting limit values

The first limits for discharges from French nuclear facilities had been set on the basis of an impact lower than the current thresholds for effects on health. It was then found that the regulatory limits established in the past were not representative of actual discharges,

This finding was all the more blatant in that the optimization efforts required by the authorities and implemented by the operators had led to a substantial reduction in the discharges. By way of example, the liquid effluents from the Flamanville power plant for activation and fission products went from 151 GBq in 1986 to 0.523 GBq in 2012.

To establish regulatory limits that encourage operators to reduce their discharges, France requires that the limits be set as low as the best available techniques will allow, taking into account feedback from experience with the discharges produced at the facilities. In recent years the ASN has undertaken an approach to revising the discharge limits such that they are close to actual discharge figures, thus encouraging the operators to keep up their efforts to reduce and control their discharges.

The lowering of discharge limit values is expressed in a reduction by the factor shown in the table below.

	AREVA NC La Hague plant	Nuclear power stations	
		900 MWe	1300 MWe
Activation products/Fission products (excluding tritium)	12	2.2	2.6
Alpha emitters	10		

Reduction factors for the radioactive liquid discharge limits defined in discharge permits since 1995

Updating of the stipulations concerning discharges according to the principles described above for all the sites requires a sustained effort over several years (almost all French facilities are currently fully regulated by provisions made in application of the above-mentioned Decree No. 95-540 or of the TSN Law). The improvements caused by the application of these provisions provide justification for continuing this approach.

3.2. The radiological impact of nuclear activities

In application of the optimization principle, the operator must reduce the radiological impact of its facility to values that are as low as reasonably possible, taking into account the economic and social factors.

The operator is required to evaluate the dosimetric impact caused by its activity. This obligation arises either from Article L1333-8 of the Public Health Code or from the regulations concerning discharges from BNIs, depending on the case.

This evaluation covers discharges from identified outlets (stacks, and discharge outfalls into the fluvial or marine environment). It also includes diffuse emissions and sources of radiological exposure to ionizing radiation present in the facility. The impact is estimated for identified reference groups. These are homogeneous groups of persons receiving the highest average dose among the entire population exposed at a given facility, under realistic scenarios This approach enables a comparison between the total dose and the acceptable annual dose limit for a member of the public (1 mSv/year) defined in Article R1333-8 of the Public Health Code.

Prior to authorization, the impact is evaluated on the basis of the required annual limit, considering the radionuclides likely to be discharged. This evaluation is reassessed each year, based on the activity of the radionuclides measured in the discharges, to which must be added the radiation exposure (due in particular to the storage of wastes). This evaluation is annually published in the ASN's annual report.

In France, liquid radioactive discharges produced by the nuclear industry have very little radiological impact.

3.3. Control of radioactive discharges

Monitoring of the discharges from a facility is primarily the operator's responsibility. The provisions regulating discharges provide for controls that the operator must implement. These controls particularly address effluents (monitoring of the discharges' activity, characterization of certain effluents before discharge, etc.) They also include provisions concerning monitoring of the environment (checking in the discharge stream, sampling of air, milk, grass, etc.) Lastly, measurements of related parameters are required where necessary (especially meteorology). The results of regulatory measurements must be recorded in registers which, in the case of BNIs, are sent to the ASN each month for checking.

In addition, BNI operators must regularly send a certain number of samples collected from the discharges to an independent laboratory for analysis. The results of these controls, called "cross" analyses, are sent to the ASN. The cross-analysis program defined by the ASN is designed to provide grounds for believing that the results obtained by the operators are accurate. Cross-analysis control programs were established for the majority of facilities. It is currently a requirement of the order of 7th February 2012 and ASN resolution 2013-DC-360 of 16th July 2013 for all BNIs.

Lastly, ASN uses unscheduled inspections to ensure that operators comply with regulatory provisions. During these inspections, the inspectors, who may be assisted by technicians from a specialized independent laboratory, check that the regulatory requirements are being met, have samples collected in the effluents and the environment, and have them analyzed by this laboratory. ASN carries out around 20 inspections with sampling per year.

3.3.1. Accounting for BNI discharges

The reduction in the activity of radioactive effluents discharged by BNIs, the changes in the categories of radionuclides regulated under discharge permits, and the need to be able to calculate the dosimetric impact of discharges on the population led the ASN to make changes in 2002 to the accounting rules for radioactive discharges.

The principles underlying the accounting rules are the following:

- For each of the regulated categories of radionuclides, the activities discharged are based on the specific analysis of radionuclides and not on overall measurements;
- The detection limits to be complied with are defined for each type of measurement;
- For each BNI and each type of effluent, a so-called "reference" spectrum is defined, i.e., a list of radionuclides whose activity must be systematically accounted for, whether or not it is greater than the decision threshold. These reference spectra, which are subject to change, are based on feedback from experience with previous analyses. When the activity is less than the decision threshold, the threshold figure is used in the accounting.
- Other radionuclides that may be locally present are included when their activity concentration is greater than the decision threshold.

As their discharge permits are renewed, these regulations have been progressively applied to almost all of the French nuclear facilities in the OSPAR area. These rules are currently a requirement of ASN resolution 2013-DC-360 of 16th July 2013.

3.3.2. Tritium

Tritium discharges from nuclear facilities are subject to permitting via the decree authorizing the construction of a nuclear installation. Their direct and indirect effects are evaluated during the impact study that accompanies the application for a permit submitted by the operator. Up to now, the medical authorities in France and abroad, as well as international health organizations, have agreed in considering that tritium has a low radiotoxicity. It is also accepted that it is not concentrated in food chains (no bioaccumulation) when found in the form of tritiated water.

France nevertheless considers that its radiotoxicity and the technical possibilities for treating it should continue to be investigated periodically, which is fully consistent with the conclusions published by ICG Bremen. For this reason the ASN wished to have a measured analysis of existing studies on this subject.

The ASN therefore decided, at the end of 2007, to establish two independent discussion groups, bringing together scientists, operators, and associations, including French experts but also foreign ones:

- The "tritium impact" group, responsible for establishing an inventory of the scientific knowledge concerning tritium's impact on health and the environment;
- The "defence in depth" group, responsible in particular for investigating the state of the art regarding the technical possibilities for treating tritium and establishing an inventory of knowledge concerning its environmental impact.

Their findings and recommendations were submitted in early April 2010. The studies highlight the small impact that tritium releases have in France. However, they do also show the need to carry out further study and research in order to supplement current data and knowledge on the behaviour of tritium in the environment. The ASN has drawn up its action plan on the basis of the recommendations made by the two working groups. This action plan includes four parts: measurements, control of discharges, environmental monitoring and impact assessment.

ASN has set up a pluralistic committee to monitor the action plan. Its last meeting was held on 4th July 2012. Some actions started in 2011 were continued in 2012:

- ASN has initiated a review of tritium emissions from all French nuclear sites, which is published on the White Paper website. This review also includes the dosimetric impact of each site and the tritium contribution to the total dose;
- the work to standardise the measurement of organically bound tritium conducted by the BNEN (Nuclear Equipment Standards Office);
- the licensees have initiated work to improve characterisation of their discharges;
- with regard to radiological impact, ASN has asked the licensees to supplement their impact assessments with a critical study taking account of a doubling of the tritium impact.

3.4. Informing the public about discharges

The ASN considers that an essential issue in the regulation of discharges is to provide a suitable forum for the stakeholders.

The public is consulted during the permitting procedures, by means of a public inquiry. The ASN ensures that the implementation of the public inquiry process allows the public and the associations involved to make their views known.

In the event of a minor change in a facility leading to an increase in the limit value of the discharges, the Decree of November 2, 2007 provides for local meetings of the Local Information Committee (CLI) and of the Departmental Council on Environment and Health and Technologic Risk (CODERST) concerning the new regulations. In 2007, a direct consultation of the public was not required in that case. In 2010, at the request of ASN, the law was amended so that consultation public is mandatory in the case of non-significant changes. ASN resolution 2013-DC-0352 of June 18th 2013 specifies the procedure.

In addition, the Environment Code was recently amended. Henceforth, the public is consulted on any individual stipulations including the requirements regarding withdrawals of water by the BNI and the discharge of radioactive effluents produced by the BNI.

Over the lifetime of the facility, the ASN ensures that the operators submit an annual report concerning the impact of their facility on the environment. This report (whose content is defined in the Order of 7th February 2012 and ASN resolution 2013-DC-360 of 16th July 2013) presents full information on discharges of effluents for the preceding year. It is sent to the Local Information Committee (CLI) for study.

In conclusion, although the radiologic impact associated with liquid radioactive discharges is very small, France is determined that its regulatory framework and operator practices will make it possible, through the application of the best available techniques, to achieve a high level of control over radioactive discharges and to obtain reductions in discharges, in line with the OSPAR strategy. France will ensure that this approach is applied in a fully transparent manner, and will involve the various stakeholders.

4. Monitoring radioactivity in the environment

The monitoring of radioactivity in the environment is an international concern, operating within two agreements:

- The EURATOM Treaty which, in its Article 35, requires Member States to establish permanent control structures for radioactivity in the atmosphere, waters, and the soil, in order to ensure checks on compliance with basic standards for the protection of the health of populations and workers against the dangers resulting from ionizing radiation.
- The OSPAR Convention, whose strategy for a Joint Assessment and Monitoring Programme (JAMP) provides for the establishment of a program of monitoring for radioactive substances in the marine environment.

In France, many actors are involved in environmental monitoring:

- the nuclear facility licensees, who monitor their nuclear sites and their surroundings;
- IRSN, who perform a monitoring of radioactivity in the environment within the national territory
- ASN, the Ministries (DGS – General Directorate for Health, DGAL – General Directorate for Food, DGCCRF – General Directorate for Competition Policy, Consumer Affaires and Fraud Control, etc.), the State services and other public players tasked with ensuring national monitoring of the territory and/or carrying out inspection or monitoring assignments in specific sectors (foodstuffs, for example, in the case of the Ministry of Agriculture);
- the approved air quality monitoring associations (local authorities), associations that conduct monitoring campaigns independently of the public authorities (CLIs, environmental protection associations).

The French National Network for Environmental Radioactivity Monitoring (RNM) federates all these players. It primary aim is to bring together and make available to the public all the environmental measurements made in a regulatory framework on the French territory. The quality of these measurements is guaranteed by subjecting the measuring laboratories to an approval procedure.

4.1. Monitoring of environmental radioactivity by the operators

Licensee prime responsibility includes monitoring the environment around nuclear sites in accordance with Order of 7th February 2012, ASN resolution 2013-DC-360 of 16th July 2013 and individual requirements (creation authorisation decree, discharge license or ASN resolution) defining the steps to be taken and their frequency, regardless of any additional arrangements made by the licensees for their own monitoring.

This environmental monitoring:

- gives a picture of the condition of the radiological and radio-ecological state of the facility's environment through measurement of regulated parameters and substances, whether or not radioactive, in the various compartments of the environment (air, water, soil) as well as in the various biotopes and the food chain (milk, vegetables, etc.): a zero reference point is identified before the creation of the facility and environmental monitoring enables any changes to be tracked;

- helps verify that the impact of the facility on health and the environment is in conformity with the impact assessment;
- detects any abnormal increase in radioactivity as early as possible;
- ensures there are no facility malfunctions, including by analyzing the ground water and checking licensees' compliance with the regulations;
- contributes to transparency and informing the public by transmitting monitoring data to the RNM.

All French nuclear facilities in the OSPAR area are subject to systematic environmental monitoring. The nature of this monitoring is adjusted to the risks and disadvantages that the facility might present for the environment, as described in the permitting documents and especially in the impact study.

Regulatory monitoring of the environment around BNIs is adapted to each type of installation, according to whether it is a nuclear power reactor, a plant, or a laboratory. Example of radiological monitoring of the environment around BNIs is defined in the following table.

Environment monitored or type of inspection	Nuclear power plant	Research laboratory or plant
Air at ground level	• 4 stations continuously sampling atmospheric dust on a fixed filter, with daily measurements of the total β activity (β_G). γ Spectrometry if $\beta_G > 2$ mBq/m^3 • 1 continuous sampling under the prevailing winds with weekly tritium measurement (^{3}H)	
Ambiant γ radiation	• 4 detectors at 1 km with continuous measurement • 10 detectors with continuous measurement at the site limits (monthly recording) • 4 detectors at 5 km with continuous measurement	• 4 detectors with continuous measurement and recording • 10 integrating dosimeters at the site limits (monthly recording)
Rain	• 1 station under the prevailing wind (monthly collector) with measurement of β_G and ^{3}H on a monthly mixture	• 2 continuous sampling stations including one under the prevailing wind with weekly measurement of β_G and ^{3}H
Liquid discharge receiving environment	• Sampling in the river upstream and at mid-discharge, for each discharge (riverside plant) or Sampling after dilution in the cooling water and bi-monthly sampling at sea (coastal plant) Measurement of β_G, of potassium (K) Continuous sampling of ^{3}H (daily average mixture) • Annual sampling in sediments, aquatic fauna and flora with measurement of β_G, of K and ^{3}H	• At least weekly sampling of water in the receiving environment with measurement of the total α activity, β_G, of K and ^{3}H • Annual sampling in sediments, aquatic fauna and flora for γ spectrometry
Groundwater	• 5 sampling points (monthly check) with measurement of β_G, K and ^{3}H	• 5 sampling points (monthly check) with measurement of β_G, K and ^{3}H • Measurement of total α activity
Soil	• 1 annual sample of topsoil with γ spectrometry	
Vegetation	• 2 grass sampling points (monthly check) with measurement of β_G, K and γ spectrometry Measurement of carbon-14 (^{14}C) and total carbon (quarterly) • Annual campaign on the main agricultural produce, with measurement of β_G, K, ^{14}C and total carbon, and γ spectrometry	• 4 grass sampling points (monthly check) with measurement of β_G, K and γ spectrometry • Annual campaign on the main agricultural produce, with measurement of β_G, K, ^{14}C and total carbon, and γ spectrometry
Milk	• 2 sampling points (monthly check) with measurement of β activity (except ^{40}K), β (^{40}K exclu), K and annually ^{14}C	• 1 sampling point (monthly check) with measurement of β activity and γ spectrometry (+ ^{3}H and ^{14}C periodically)

Example of radiological monitoring of the environment around BNIs

4.2. Monitoring of environmental radioactivity on the national territory

One of the duties of IRSN is to ensure a monitoring of environmental radioactivity on the national territory.

It is ensured through measurement and sampling networks dedicated to:

- air monitoring (aerosols, rainwater, ambient gamma activity);
- monitoring of surface water (watercourses) and groundwater (aquifers);
- monitoring of the human food chain (milk, cereals, food intake);
- terrestrial continental monitoring (reference stations located far from all industrial facilities).

It uses two approaches for this:

- continuous on-site monitoring using independent systems (remote-monitoring networks) providing real-time transmission of results. This includes:
    - the Téléray network (ambient gamma radioactivity of the air); the density of detectors in the network is going to be increased around the nuclear sites in the zone of 10 to 30 km around the BNIs to reach around 450 detectors (there were 163 measurement detectors in 2012);
    - the atmospheric aerosols radioactivity measurement network;
    - the Hydrotéléray network (monitoring of the main water courses downstream of all nuclear facilities and before they cross national boundaries);
- processing and measurement in a laboratory of samples taken from the various compartments of the environment, whether or not close to facilities liable to discharge radionuclides.

Monitoring of the Atlantic, Channel, and North Sea coasts involves OSPAR regions 1, 2, and 3, as defined by the RSC.

The radioactivity levels measured in France are stable and situated at very low levels, generally at the detection sensitivity threshold of the measuring instruments. The artificial radioactivity detected in the environment results essentially from fallout from the atmospheric tests of nuclear weapons carried out in the 1960's, and from the Chernobyl accident.

Traces of artificial radioactivity associated with discharges can sometimes be detected near installations. To this can be added very local contaminations resulting from past industrial incidents or activities, and which do not represent a health risk.

The selection of environmental sampling stations and measurements is based on the following objectives:

- To contribute to an assessment of the environmental impact of various sources of radioactivity (evaluate the levels of radioactivity, monitor its development in space and time, and identify and characterize the sources of the radionuclides);
- To contribute to an evaluation of human radiologic exposure (in particular, to quantify radioactivity levels in foodstuffs);
- To contribute to the detection and monitoring of a possible radiologic event and to informing the public authorities;
- To contribute to compliance with the regulations (checking the conformance of practices with respect to the regulatory framework, and cross-checking the operator's own monitoring)

In light of these objectives, the seacoast monitoring plan comprises:

- Reference stations enabling characterization of the background noise and pollution sources other than the discharges from major nuclear facilities, and monitoring the contributions of major rivers;
- Stations within the area of influence of nuclear facilities located on the coast, enabling a monitoring of the spatial distribution and development over time of the radiologic state of the marine environment.

Optimization of the monitoring program relies on knowledge acquired from radioecologic studies, feedback from experience with the monitoring networks, and use of dispersion models developed by the IRSN.

The radiologic monitoring program for the marine environment implemented by France on its seacoast provides a comprehensive response to the objectives set forth by the RSC under the OSPAR Convention. In particular it leads to the acquisition of extended time series of measurements, which are made available to the RSC for the preparation of periodic assessment reports (for instance Third periodic evaluation, OSPAR Publication N° p00455 - 2009). France thus annually provides the RSC with the following environmental measurements:

OSPAR Region	STATION	Environmental and radionuclide categories				
		Seawater (surface)			Molluscs	Algae
		^{3}H	^{137}Cs	$^{239.240}Pu$	$^{239.240}Pu$	^{137}Cs
1	Roscoff	A	A			S
	Brest	Q	Q			
	Concarneau	A	A			S
	Pornichet	S	A			
	Oléron	S	A			Q
	Arcachon	A	A			
2	Carteret	Q			S	Q
	Goury	Q	Q	A	Q	Q
	Cherbourg	Q				
	Barfleur	Q			S	Q
3	Honfleur	Q				Q
	Wimereux	A	A			S

A: Annually, Q: Quarterly, S: Semi-annually

Sampling and measurements from monitoring of the French seacoast, representing the concentration data sent to RSC OSPAR

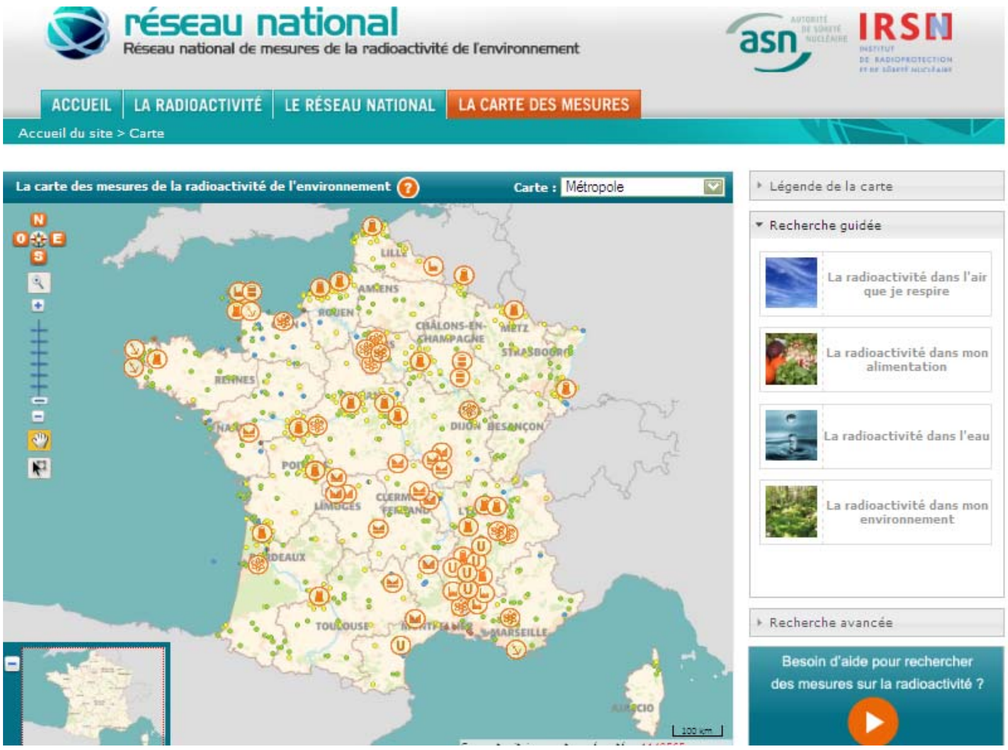
Sampling stations on the French seacoast sending measurements to RSC OSPAR

Twelve stations shown on the above map are distributed along the French seacoast, with a higher density in the Channel where the majority of the coastal nuclear facilities are located.

This effort to optimize the collection of concentration data for OSPAR is accompanied by an effort to develop methods to make use of them as part of the RSC's work. In fact, France has played a key role in leading the Intersessional Correspondence Group (ICG-Stats) in recommending the statistical methods to be employed by RSC in compiling its periodic assessment reports on the implementation of the OSPAR strategy for radioactive substances. In particular, it has suggested rigorous methods for conducting statistical tests while taking into account the presence in the data series of values lower than the detection limits (Fiévet and Della Vedova, *Journal of Environmental Radioactivity*, 101:1-7, 2010). France has also played a key role in the application of these data for estimating the impact on the biota. These methods have been employed by the RSC since its third periodic assessment report (Third periodic evaluation, OSPAR Publication N° p00455 - 2009).

4.3. The national network for environmental radioactivity measurement

As part of the implementation of the EURATOM 96/29 directive (basic standards for the protection of the health of the population and workers against ionizing radiation) and the 2003/4/CE directive (public access to information concerning the environment), France has established a national network for measuring radioactivity in the environment, designed to provide the public with the results of the monitoring of environmental radioactivity and with information concerning the nuclear industry's impact on health throughout France. This database is intended to contribute towards informing the public through the development of an internet portal enabling access to radioactivity measurements and their interpretation in terms of radiologic impact. The development and validation of the portal's contents were completed in 2009, and it was opened to the public in 2010 (http://www.mesure-radioactivite.fr/).



National network for environmental radioactivity measurement website

The public availability of the results from monitoring of environmental radioactivity, and information concerning the nuclear industry's impact on health throughout France, is ensured by the regulatory obligation imposed on institutional actors and on nuclear operators to publish the results of mandatory environmental monitoring on the national network's website. The regulations require that the mandatory monitoring measurements of radioactivity in the environment are carried out in approved laboratories.

Non-mandatory measurements carried out in approved laboratories (including the laboratories of associations) may also be published on the national network's website.

In order to meet this transparency goal, the RNM launched a website on 2nd February 2010 to present the environmental radioactivity monitoring results and information on the health impact of nuclear activities in France. In order to guarantee the quality of the measurements, only those taken by an approved laboratory or by IRSN may be communicated to the RNM.

The website is organised around three topics (radioactivity, the national network and the measurements map) and can be used to obtain information about radioactivity (what is radioactivity? how is it measured? what are its biological effects?), about the RNM (operation, network participants, laboratory approval procedure), plus access to a database containing all the radioactivity measurements taken nationwide (almost 1,000,000 measurements). The RNM management report is also available on it. At the end of 2012 IRSN published a report on the radiological state of the French environment for 2010 and the first half of 2011. This report is drawn for the first time using data from the RNM[2].

4.4. Quality of measurements in the environment

Articles R.1333-11 and R.1333-11-1 of the Public Health Code make provision for the creation of a National Network for Environmental Radioactivity Monitoring (RNM) and a procedure for having the radioactivity measurement laboratories approved by ASN. The RNM procedures were defined by an ASN resolution (approved ASN resolution 2008-DC- 0099 of 29th April 2008).

This network is being deployed for two main reasons:

- to ensure the transparency of information on environmental radioactivity by making the results of this environmental monitoring and information about the radiological impact of nuclear activities in France available to the public;
- to continue a quality assurance policy for environmental radioactivity measurements by setting up a system of laboratory approvals granted by ASN resolution, pursuant to Article L.592-21 of the Environment Code.

The approvals cover all components of the environment, water, soils or sediments, all biological matrices (fauna, flora, and milk), aerosols and atmospheric gases. The measurements concern the main artificial or natural, gamma, beta or alpha emitting radionuclides, as well as the ambient gamma dosimetry.

In total, about fifty types of measurements are covered by approvals. There are just as many corresponding inter-laboratory comparison tests. These tests are organised by IRSN in a 5-year cycle, which corresponds to the maximum approval validity period.

Besides making information about environmental radioactivity available to the public, France believes that the issue of the quality of the information is a primary concern, particularly in a context as sensitive as that of radioactivity in the environment. The importance of this matter becomes apparent when a comparison is made of the results obtained by the various actors supplying data to the national environmental radioactivity network. It is therefore essential to begin by ensuring the technical and organizational abilities of the laboratories.

This approach is very much in line with the quality objectives set by the strategy for a Joint Assessment and Monitoring Programme (JAMP).

In order to pursue a policy aimed at guaranteeing the quality of measurements of environmental radioactivity, a system for approving laboratories was introduced.

The approvals cover all of the environmental matrices: water, soils and sediments, biologic matrices (fauna, flora, and milk), aerosols, and atmospheric gases. The measurements include the principal artificial and natural radionuclides, alpha, beta, and gamma emitters, and ambient gamma dosimetry.

[2] http://www.irsn.fr/FR/expertise/rapports_expertise/Documents/environnement/IRSN_surveillance_France_2010-2011.pdf

In total, some fifty types of measurement can be covered by an approval. There are a corresponding number of inter-laboratory comparison trials. These trials are organized by IRSN over a five-year cycle, corresponding to the maximum duration of an approval's validity.

4.4.1. Procedure for approving laboratories

The abovementioned ASN resolution 2008-DC-0099 of 29th April 2008 specifies the organisation of the national network and sets the approval arrangements for the environmental radioactivity measurement laboratories.

The approval procedure includes:

- presentation of an application file by the laboratory concerned, after participation in an inter-laboratory test (ILT);
- review of it by ASN;
- review of the application files – which are made anonymous – by a pluralistic approval commission which delivers an opinion on them.

The laboratories are approved by ASN resolution, published in its Official Bulletin.

This resolution obliges BNI licensees to have approved laboratories take the environmental radioactivity monitoring measurements required by regulations.

The approval commission is the body which, for the RNM, is tasked with ensuring that the measurement laboratories have the organisational and technical competence to provide the network with quality measurement results. The commission is responsible for giving ASN its proposed approval, refusal, revocation or suspension of approval. It decides on the basis of an application file submitted by the candidate laboratory and its results in the ILTs organised by IRSN.

The commission presided over by ASN comprises qualified persons and representatives of the State services, laboratories, standardising authorities and IRSN. ASN resolution CODEP-DEU-2013-061297 of 12th November 2013, for appointing candidates to the environmental radioactivity measurement laboratory approval commission, renewed the mandates of the commission's members for a further five years.

4.4.2. Approval conditions

Laboratories seeking approval must set up an organization meeting the requirements of standard NF EN ISO/IEC 17025 concerning the general requirements for the competence of calibration and test laboratories.

In order to demonstrate their technical competence, they must take part in ILTs organised by IRSN. The ILT programme, which now operates on a five-yearly basis, is updated annually.

It is reviewed by the approval commission and published on the national network's website (www.mesure-radioactivite.fr).

The ILTs organised by IRSN can cover up to 70 laboratories in each test, including a few foreign laboratories.

To ensure that the laboratory approval conditions are fully transparent, precise assessment criteria are used by the approval commission. These criteria are published on the national network's website.

IRSN organised 42 ILTs since 2003 covering 47 types of approvals. Most of the approved laboratories specialise in water monitoring, with 58 laboratories holding up to 13 different approvals for monitoring of this medium. About forty laboratories are approved for measurement of biological matrices (food chain), atmospheric dust, air, or ambient gamma dosimetry. About 30 laboratories deal with soils. Although most of the laboratories are competent to measure gamma emitters in all environmental matrices, only about ten of them are approved to measure carbon-14, transuranic elements or radionuclides of the natural chains of uranium and thorium in water, soil and biological matrices.

In 2012, ASN issued 105 approvals and extended about sixty. On 1st January 2013, the total number of approved laboratories stood at 63, which represents 810 approvals of all types currently valid.

The detailed list of approved laboratories and their scope of technical competence is available on www.asn.fr.

In conclusion, France has set up a system for monitoring environmental radioactivity that meets the objectives of the OSPAR strategy both in terms of coverage of the French portion of the OSPAR area, and of the quality of the monitoring data provided under the agreement concerning the program for monitoring radioactive substances in the marine environment.

PART II - APPLICATION OF THE B.A.T. TO THE RADIOACTIVE DISCHARGES OF THE AREVA NC LA HAGUE FACILITIES

1. SITE CHARACTERISTICS

1.1. Name of site

Établissement AREVA NC de La Hague, formerly Établissement COGEMA de La Hague.

The plants of the AREVA NC La Hague site

1.2. Type of facility

Spent nuclear fuel uranium and plutonium recycling facility and associated functions: interim storage pools, liquid effluent treatment unit, plutonium recovery unit in wastes, waste conditioning units, fission products vitrification units, interim storage for wastes before return to foreign customers or disposal in France, discharge control laboratory and environmental control laboratory. Redundant facilities are being decommissioned and legacy waste recovered and conditioned.

1.3. Year of commissioning/licensing/decommissioning

The first reprocessing plant on the La Hague site, UP2, designed for the French natural uranium gas graphite reactor fuels with a capacity of more than 600 tU/y, came into operation in 1966 with the corresponding effluent treatment plant STE2 very soon after.

Faced with the development of reactors using enriched uranium oxide and ordinary water (known as "light water reactors"), France proceeded to adapt its reprocessing plants to deal with the fuels used in the reactors of these series. It was in response to this requirement that a new "High Activity Oxide" head-end of UP2 (HAO) was brought into service in 1976 to carry out the preliminary operations of shearing and dissolution of "light water" fuels, with a corresponding reference capacity of 400 tU/y.

The later development in France and in the world of these light water reactors led COGEMA to increase the reprocessing capacity. First, extensive modifications were planned to increase UP2-HAO plant reference capacity from 400 to 800 tU/y for light water reactor fuel. The implementation of these modifications, under the designation UP2-800, was completed in 1994. Secondly, a completely new plant, with the same reference capacity (around 800 tU/y of light water reactor fuel), was designed and built on the same site, intended to be used solely for the reprocessing of foreign reactor fuels during the first ten years of its operation. This plant came into operation in 1990.

These new plants were accompanied by a new effluent treatment plant, named STE3, which came into operation in 1987. For the first time, STE3 allowed the direct conditioning of waste resulting from the treatment of the effluents of the reprocessing operations.

The oldest units of UP2 being nearly 30 years old when UP2-800 started in 1994, some of them have been subject to refurbishment and a completely new plutonium tail end (purification, conversion and conditioning) using new process equipment, named R4, was built and came into operation in 2002.

In addition, a new facility called ACC (hulls compaction facility), was set up and started in 2002 in order to decrease the volume of conditioned solid waste of both UP2-800 and UP3-A. This facility allows reducing the volume of technological and structural waste (hulls and end-pieces) by a factor of five.

On January 10th 2003, new authorisation decrees have been published for STE3, UP2-800, and UP3-A. The purpose was essentially to give some operational flexibility to the plant. The authorized capacity limit of the storage pools has been increased, the allowed production limit of each plant (UP2-800 and UP-3A) has been brought up to the usable capacity of 1,000 tU/y, the total production limit of the site being set at 1,700 tU/y. The industrial reprocessing of MOX fuels and new fuels (such as higher burn-up fuels as well as MTR fuels) is authorised as well as the treatment of products coming from outside the site, provided they are compatible with the facility process.

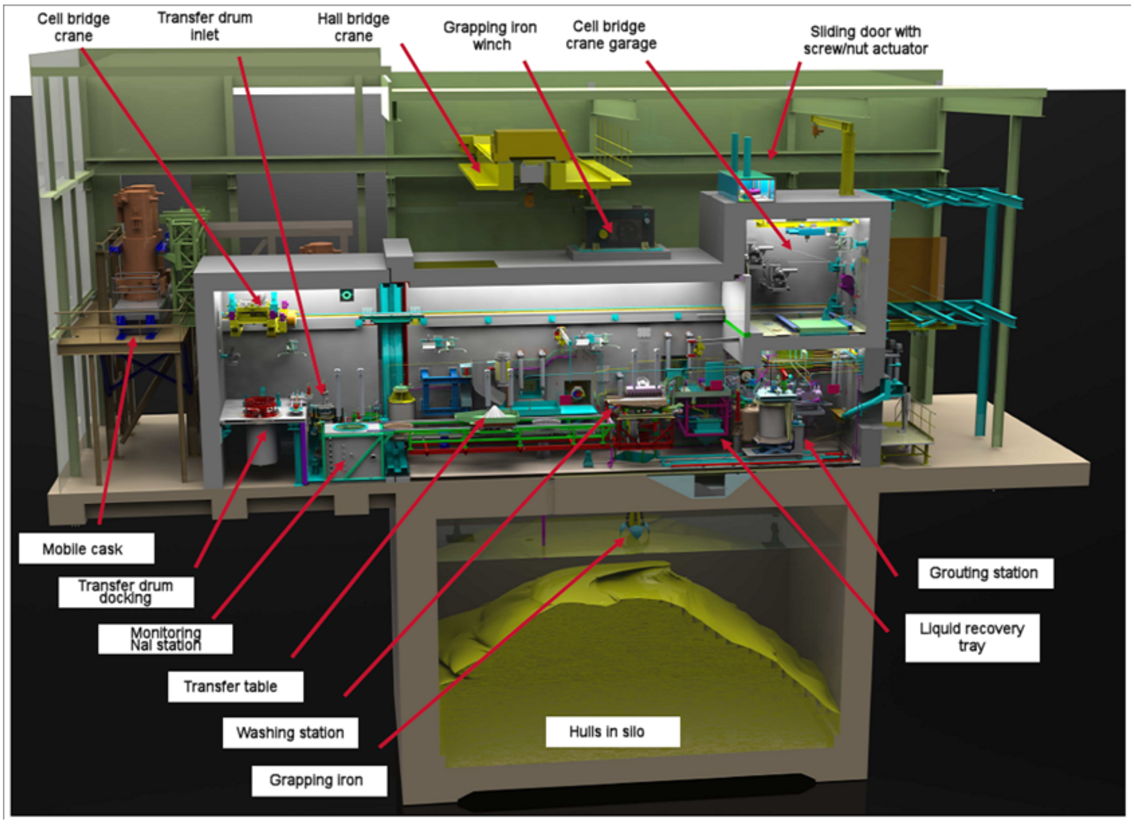
Though none of the changes induced significant modifications of the facilities, or any increase of the discharges, to take into account the progress of the techniques, apply the BAT principles and encourage the continuous improvement performed by the operator, the authorisation limits of the associated discharge application order (also published on January 10th 2003) were lowered for most of the nuclides, and applied to a finer cutting out of the types of discharges and radionuclides.

In compliance with the discharge order of January 10th 2003, which states that the discharge authorisation limits were to be reviewed after four years, a complementary ministerial order was set in force on January 8th 2007. It brought another set of significant reductions of the authorisation limits (presented in § 2.5).

Concerning decommissioning, it has been undertaken on two pilot plants belonging to the French CEA, a small industrial isotope production plant, and one for the reprocessing of fast neutron reactor fuels, 1 kg/day capacity (decommissioning completed). The operation of this plant has ceased in 1979, the equipment has been rinsed from 1979 to 1981, then the equipment has been removed from 1989 to 1995 and the premises cleaned up from 1996 to 2001. The premises are now free of radiological control. One can enter them in civilian clothes, without the requirement of any monitoring. In several other buildings, the premises have been cleaned up and reused to install the equipment used in more elaborated processes.

The plants that came into operation in 1966 and 1976 have been submitted since 2003 to CDE standing for "Cessation Définitive d'Exploitation", that is to say final stop of operation. It consists, using the normal process and maintenance equipment as well as the usual operating team, in removing as much as possible radioactive substances and contaminated equipment and sending them to their normally used destination, either in the process for reusable substances or to the waste for the others. Since this phase uses only the means intended for the normal operation, it does not require a specific ministerial decree, only a decision of the French Nuclear Safety Authority (Autorité de Sûreté Nucléaire – ASN) which checks that the operation is consistent with the original safety file.

The next stages, the MAD, standing for "Mise à l'Arrêt Définitif", that is to say final cessation of operation, and the DEM, standing for Démantèlement (decommissioning) are of a different nature, requiring specific means for example for the decontamination of the structure of the buildings and other competences than those of the usual operating team. It thus requires a specific safety file and a new ministerial decree. For this purpose, AREVA NC (that succeeded to COGEMA) has submitted in February 2008 a file requiring such an order for the MAD/DEM of the HAO workshop, this one comprising a transportation cask unloading facility, a fuel storage pond and its filtering unit, a fuel shearing and dissolution unit, a clarification unit and two storage units for the structural debris of fuel. The setting of such a decree requires a public enquiry that has taken place in November 2008. The ministerial decree authorising the MAD/DEM on the Nuclear Facility N°80 (HAO workshop) has been signed by the Prime Minister on July 31st 2009 and the corresponding operations have immediately begun. Some of them generate exceptional discharges, authorised and reported as such.



<u>Retrieval and conditioning of legacy waste: LWR hulls stored in the HAO silo</u>

Apart from the decommissioning activities, the other exceptional type of operation is RCD, standing for "Reprise et Conditionnement des Déchets" meaning retrieval and conditioning of legacy waste. Up to 1990 around, some by-products that had no agreed disposal channel have been either stored in silos or conditioned in provisional form. This is for instance the case of the hulls from LWR fuels that were stored in bulk in the HAO silo. For safety and consistency reasons, it is important that these by-products are retrieved and conditioned in forms that allow them to be directed to agreed disposal channels.

1.4. Location

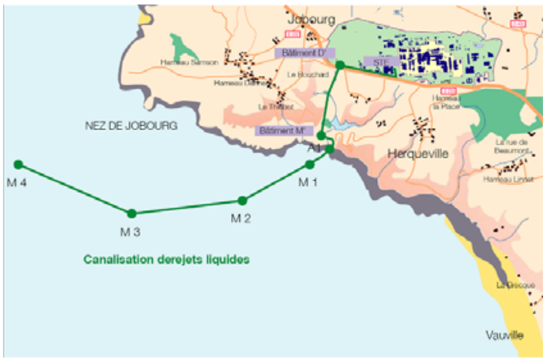
The plant is located on the northwest tip of the Cotentin peninsula, 6 km from the Cap de la Hague, 270 km west from Paris and 20 km west of the Cherbourg conurbation (nearly 90,000 inhabitants). The plant is located in the central part of the Jobourg plateau, at the highest point reaching 180 m above sea level. It covers an unbroken area of 2.3 square km.

1.5. Receiving waters and catchment area

Receiving water is the Channel, 1.5 km west from the Cap de la Hague at a place selected as the one where the tidal streams have the highest velocity (up to 10 kt, that is to say around 5 m/s). Discharge of radioactive liquid waste is carried out during a relatively short time, beginning at a precise moment before the high tide, to ensure the best dilution. The dilution rate is around 500,000 at a distance of 1 km from the end of the discharge pipe, and 1,000,000 in the vicinity of Goury, the nearest fishing harbour. The diluted activity is then transported to the North Sea by residual tidal currents.

The Safety Authority, relying on the regulations, sets the technical specifications applicable to the limits of the discharges submitted to authorisations. These require that the operator monitors radioactive discharges before and during the emission. Before the discharge the monitoring is aimed at:

- Verifying that the limits set for the discharge of the effluents are complied with, and, if these limits are not complied with, that the effluents are sent to appropriate treatment equipment;
- Determining the parameters of the discharges (agenda and flow), taking into account the regulations set in order to insure the optimal dispersion of the discharges, and particularly the limits set by the discharge authorisations.



The discharge point location

Thus, each emission is performed after the analysis of representative samples by the operator. The volume and radioactivity discharged are transcribed on a monthly register communicated inter alia to the ASN.

A large number of streams having their source on the plateau flows the northeast and southwest slopes to the sea. An important part of the southwest basin is collected in the Moulinets valley, in an impoundment built by the coast to hold 400,000 m^3 of fresh water used for supplying the plant process. All these streams are submitted to the January 8th 2007 French ministerial order prescriptions (that complements the January 10th 2003 ministerial order), defining radioactive and physicochemical concentration limits, and are carefully monitored. No radioactive effluent is discharged by the AREVA NC plant in these streams.

1.6. Production

Annual production over the reporting period is displayed in table below. Also displayed is the equivalent electrical energy delivered during their use in reactor by the spent fuel elements that have been reprocessed during the considered year.

This indicator is more relevant than the mere tonnage of uranium treated, because:

- It represents the service rendered by the reprocessed fuel, and can then be used as a reference for the normalisation of the data, which are then freed from the variability of the service rendered,
- It is practically proportional to the fission products inventory of the spent fuel, which contains the most part of the radioactivity, and represents then the radioactive input to the process, i.e. the reference for the global decontamination factor of the plant.

These points are dealt with in § 2.3.3 below.

Tons of initial uranium	2007	2008	2009	2010	2011	2012
UP2-800	458[I]	299[II]	243	595	495	555
UP3-A	490	638	686	454	550	468
SITE TOTAL	948[I]	937[II]	929	1049	1045	1024
Equivalent Energy (GW.y)	38.25	31.31	32.3	38.6	39.1	39.3

[I] including 31.5 tons of MOX. [II] including 5 tons of MOX.

Annual site production during the reporting period

It is worth noting that a part of the equivalent energy displayed corresponds to a service that has been rendered to some other contracting parties to OSPAR than France.

2. DISCHARGES

2.1. Description of systems in place to reduce, prevent or eliminate discharges of radioactive substances to the marine environment

2.1.1. General principles

The general principles applied for the design and operation are the following ones:

- Use of a very stringent system of containment to prevent losses, a minimum of two complete physical barriers being installed between the radioactive material and the environment.
- Use of the natural radioactive decay as a basis principle, in order to substantially decrease the activity of the short half-life radionuclides. Fuel, after reception, is driven towards storage pools, where it stays for an average period of around 5 years (as an example the ruthenium 106 residual activity is then reduced by a factor of 32 between the fuel arrival and the beginning of the reprocessing step).
- Optimisation of the destination of by-products (washing solutions, hulls rinsing effluents, solvent washing), the first priority being to recycle them as much as possible into the process.
- Second priority, for the by-products that cannot be recycled, being to send them as much as reasonably possible to solid waste (with a preference for vitrification, and to compaction and/or grouting if it is not possible to vitrify). The remainder is discharged in either the atmosphere or the sea, according to the technical possibilities, in order to minimise the impact on the representative persons.
- Exposure of workers and risks for population and workers are taken into account to balance the options, in consistency with the ICPR principles.

A transfer gallery

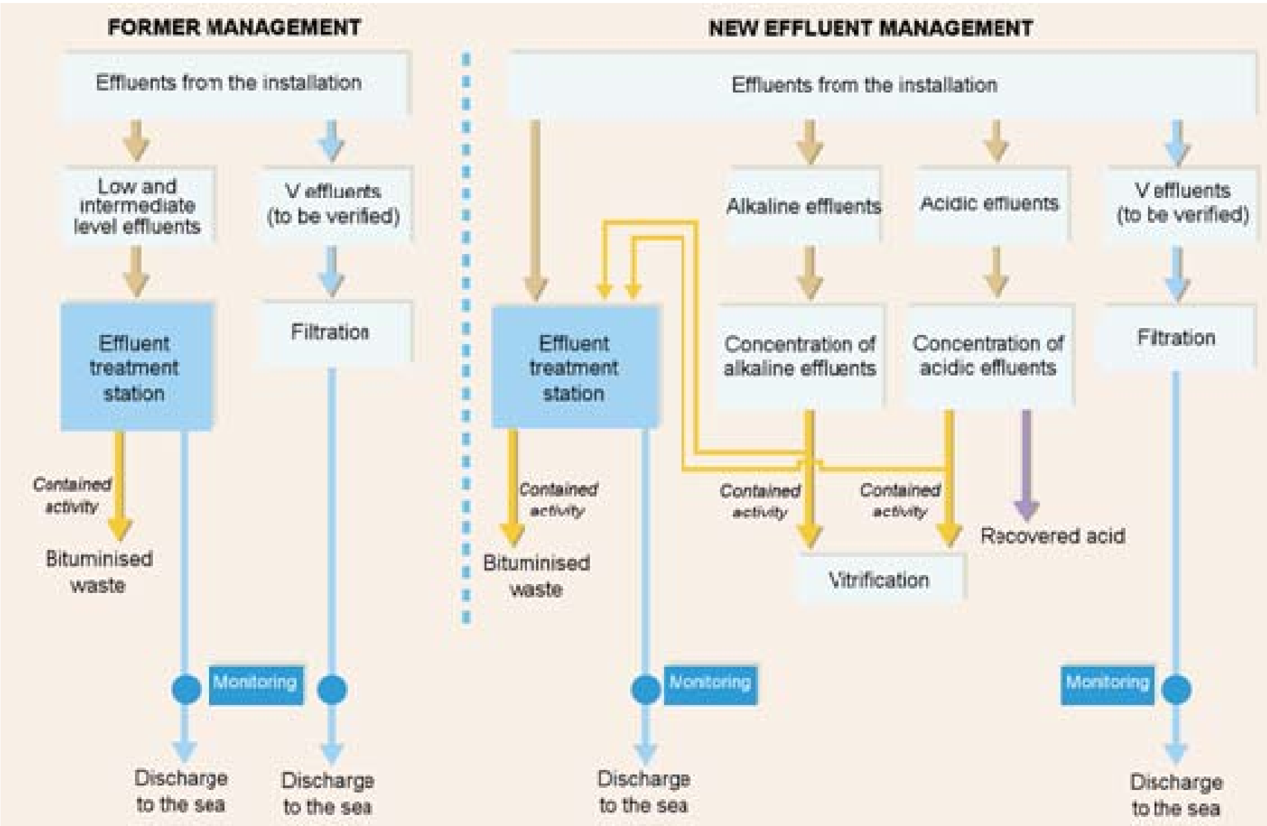
Consequently, the effluents are collected, then treated as much as possible to recover all reagents, which are purified and if necessary converted in order to recycle them into the process. The remainder is concentrated in such a way that the radioactive elements contained can be sent to solid waste, most of them to vitrification, which is the most compact and efficient way of conditioning radioactive elements in terms of material containment. Some processes that used to generate effluents that could not be concentrated or vitrified (such as some laboratory analyses effluents) have been substituted for other ones in order to withdraw some active flows.

Major fluxes concerned by recycling are vacuum groups condensates, washing or decontamination effluents, pool effluents, evaporator distillates, and solvent treatment effluents.

For instance, all aqueous solutions used to rinse structural elements (end-pieces and debris of cladding called hulls) are recycled to prepare the dissolution reagent from highly concentrated nitric acid, itself coming from recycling, concentrated and purified by evaporation after that other products (fission products, uranium and plutonium) have been removed from its flow in the process. This is also the case for spent solvent and diluent, which are purified from the radioactivity and the degradation products they contain by distillation under vacuum in a specific evaporator. The remaining fraction, in this case, cannot be vitrified and it is grouted as solid waste after calcination in a dedicated unit. This by-product recycling principle is a first and very important mean of reducing the discharges.

For the solutions that cannot be recycled, previous liquid effluents management was based on an activity level sorting out. High activity effluents were all sent to vitrification, medium and low activity effluents were collected and sent separately to the effluent treatment plant STE3, in the same batches whatever their origin, their acidity and their chemical content (provided they could be accepted by STE3 equipment and process). Very low activity effluents, in fact those which receive no activity in normal operation, called “V” effluents, meaning “to be verified”, were stored, controlled by batches to check that their activity was below the prescribed limits, then filtered and discharged to the sea between the active effluent discharges which take place during the high tidal stream periods.

2.1.2. The “new effluent management”



The former and new effluent management

In 1996, a “new effluent management” system has been introduced. The high activity effluents are still regularly sent to vitrification. The medium and low activity effluents are now collected separately on an acidity basis, the acid ones on one side, and the alkaline ones on the other side. Instead of being sent to the effluent treatment plant to be sorted out according to their activity level, they are concentrated in dedicated evaporators, for acidic effluents and for alkaline effluents respectively, which were installed in 1998 in UP3-A. The main part of the feed of the acidic and alkaline evaporators comes out as distillates, practically free of contamination, which are sent to the “V” effluents and discharged with them. The remaining concentrates take the whole radioactivity, becoming thus high activity effluents (of very little volume compared to the original ones) and are then sent to vitrification with these ones. This is a second and also very important mean not only of reducing effluents, but also of reducing solid waste volume, which contributes to the safety of the disposal.

This result is due to the fact that the concentration by distillation in evaporators is much more efficient than the chemical process. Since only very few by-products cannot be sent to the evaporators, the number of annual discharges from STE3 (that result from the chemical treatment of a complete batch) has been drastically reduced, from up to several hundreds to an average near one (up to two some years, none some years[3]). The practical consequence is that some discharges do not occur during the year the by products were generated, because these had to wait for the batch to be completed to treat them.

As a result, the greatest part of the discharges is now under the form of very low activity V effluents, for which the activity is very often "less than" and is conservatively accounted for the threshold value.

These technical developments became possible in UP2-800 and UP3-A because of the significant improvements brought by the new implementation of the process in these plants. This one led to substantial reduction of the quantity and of the activity (better Decontamination Factors) of the effluents. Consequently, this permitted to concentrate the effluents in evaporators of reasonable size which were possible to install in free spaces of the plants.

The resulting effects of New Effluent Management implementation can be seen in table below.

2.1.3. Other improvements

The case of the analytical laboratory analysis effluents is a specific one. The activity they contained represented a significant part of the alpha emitters and a minor part of the other emitters in the discharged liquid effluents before volume reductions began. After most of the volume reduction measures had been implemented, the other emitters' proportion became also significant. Most of them could not be recycled because the reagents used for the analysis led to compounds which were not compatible with the necessary treatments. The most important measures taken were to develop new technologies of automated on line measurements which do not need to take samples from the process, thus suppressing an effluent flow, and also to develop the use of the technology of plasma torch spectrography. This technology needs only very small samples and does not use unusual reagents, suppressing the corresponding effluent flow. Some of the remaining plutonium solutions analyses were the cause of the high alpha activity content of the effluents coming from the analytical laboratory. Since 2001, a new plutonium recovery management on this flow allows a significant reduction of the alpha activity driven to the effluents from all of the laboratories and the sampling units of the AREVA NC La Hague site.

Following the implementation of the better controlled process of STE3 (as described in previous BAT application Reports) since 1989, which led to substantial reductions of the activity of the discharges, the implementation of the principles described above brought new significant reductions, moreover with a lesser volume of solid waste. The radioactive elements instead of being bituminised or cemented, are sent to vitrified wastes accepting much higher activity concentrations. Thus, the substantial decrease of the discharges is not obtained at the detriment of the volume of solid waste, but together with a better compactness of these (3,000 bitumen drums have been replaced by less than one glass canister).

In 2002, the two workshops of UP2-400 that were still operated, MAU and MAPu (Medium Activity Uranium and Plutonium) have been replaced respectively by a part of T3 and the new R4 workshop. The replacement of pulsed columns or mixers-settlers by centrifugal extractors induces a lower degradation of the solvent, resulting in less effluent.

The replacement of UP2-400 units by more sophisticated facilities (R4 as the last example) led then to a significant reduction in beta emitters discharges to the sea, these decreased by a factor of two between 1999 and 2004.

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[3] 2 in 2009, none in 2010 and 2011, 1 in 2012.

Solvent and diluent are now continuously purified in the TEO (Organic Effluent Treatment) units, by distillation under vacuum. Aqueous effluents are sorted out according to their acidity, following the principles of the NGE (New effluent management) implemented in the UP3-A plant, and concentrated in dedicated evaporators. The concentrates that gather most of the radioactivity are to be dried and incorporated in the vitrified waste, the clean distillates are as much as possible recycled into the process. This allows the reduction of both the volume and activity of both the alpha and beta liquid discharges.

One point of the New Effluent Management has not been implemented. Since the beginning of the tests in 1996, it has appeared that sending the concentrates of the alkaline effluents concentration unit (CEB) to T7 (vitrification workshop of the UP3-A plant) was inducing foaming and plugging of the feeding unit of the vitrification workshop. These tests have been halted in January 2007. While awaiting a solution the concentrates have been sent to STE3 for chemical precipitation treatment.

The piping above an effluent tank

This treatment being then the main remaining source of ruthenium discharges to the sea, extensive R&D has been launched to reduce these discharges. The source of the problem encountered in T7 has been identified as the presence of traces of degradation products of the solvent used in the process (organic-phosphoric compounds). The solution selected for further investigation is a chemical treatment of the concentrates in order to completely oxidise these compounds with hydrogen peroxide in presence of nickel (Fenton reagent) after acidification of the concentrates (see § 6, Additional Information, for the detail of the other solutions explored).

- The formal qualification of this process was achieved in 2004, after:
- Tests of industrial feasibility of the process;
- Optimisation of the process with inactive simulated solutions;
- Validation tests at laboratory scale with real solutions taken from the T2 workshop;
- Qualification of the reference process, by comparison between inactive and active tests;
- Assessment of the impact of the process implementation, in terms of by-products, residual hydrogen peroxide, corrosion, radiolysis, criticality, calcination and vitrification.

The complementary equipment to be installed in T7 has then been designed, the administrative authorisation for its installation and active use required and obtained, the equipment installed and started. Several test campaigns have been performed in 2008, with a satisfactory performance level.

The results of these campaigns have been thoroughly analysed, in order to determine the optimum industrial production parameters. It appeared that the time required for the oxidisation reaction to be complete is in fact longer than expected and does not allow the treatment of the full flow of the alkaline effluents. Only around half of this flow can be sent to vitrification, the remainder being sent as previously to the chemical treatment. Moreover, the Fenton reagent is in the scope of the REACH regulations. R&D is going on to improve the process.

2.1.4. Results

These items show how the best techniques, concerning as well processes as abatement systems, are developed and used on the AREVA NC La Hague plants as soon as they become available (that is to say *inter alia* once they have been qualified and authorised), and how they induce reductions in the volume and the activity of the effluents, which appear clearly in table below, and in the corresponding impact.

Other techniques are being studied but not yet installed, as detailed in § 6, Additional Information.

2.2. Efficiency of abatement systems

Global efficiency of the system, relative to discharges, is measured through a transfer function F_n, which is the ratio of the outgoing activity to the activity of the same nuclide in the fuel entering the process. One often uses Decontamination Factor (DF), which is the reverse of the transfer function. Transfer functions for the marine pathway and for the radionuclides quoted above are shown in table below:

	F sea
137 Cs	10^{-7}
99 Tc	10^{-4}
Pu	$<10^{-7}$

Transfer functions of nuclides

An overall transfer function for total alpha can be estimated at about 10^{-7} over the period.

Concerning total beta, no global transfer function can be drawn since abatement techniques do not have the same efficiency over the range of radionuclides covered.

Details about abatement techniques are given in Appendix 1. They reflect the current situation, with the improvements obtained upon STE3 chemical treatment, and the technical achievements since the setting up of new evaporators in R2/T2.

2.3. Annual liquid discharges

2.3.1. Nuclide-specific data (OSPAR Annual Report on Liquid Discharges)

Monitored discharge values are reported annually to OSPAR through OSPAR Annual Report on Liquid Discharges.

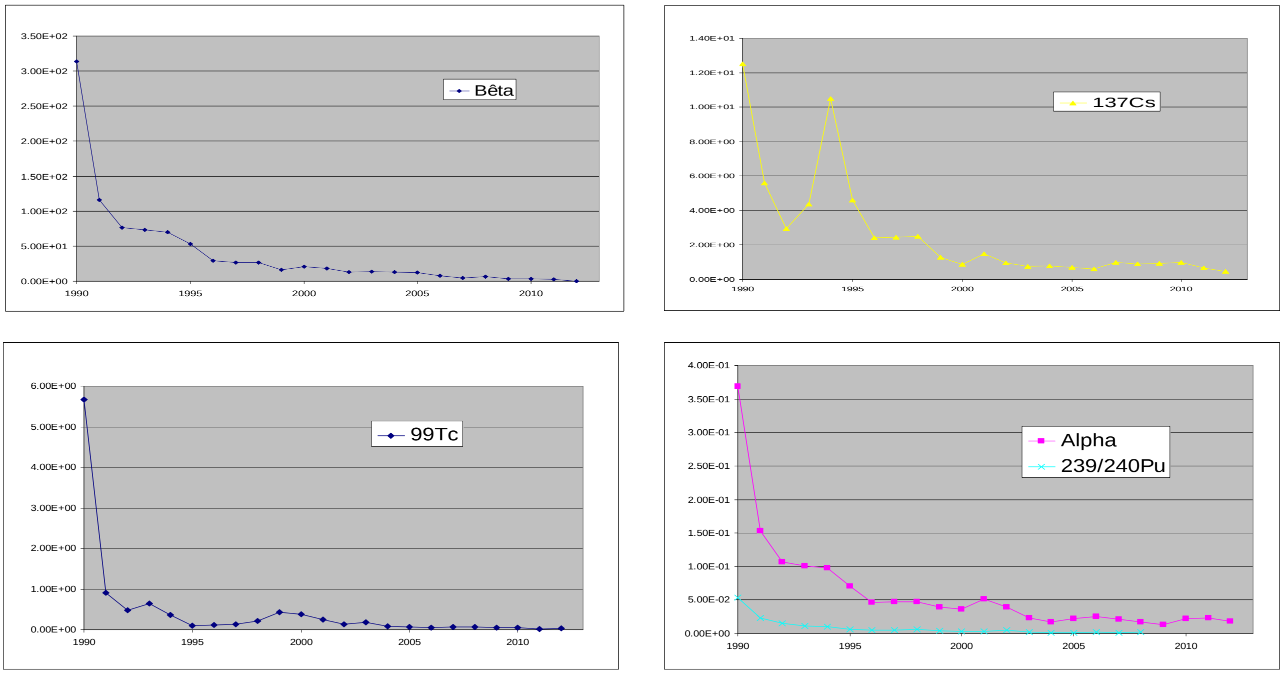
Annual liquid discharges for the last two periods and back to 1999 are displayed in table below.

The status of the annual discharges can be found since 2004 in the annual report of environment monitoring which is required by the § c) of the 32nd article of the January 8th 2007 ministerial order that complements the January 10th 2003 ministerial order.

TBq/annum	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
3 H	1.30E+04	1.10E+04	9.60E+03	1.20E+04	1.20E+04	1.40E+04	1.40E+04	1.10E+04	1.20E+04	8.20E+03	9.10E+03	1.00E+04	8.90E+03	1.20E+04
14 C	9.90E+00	8.50E+00	7.20E+00	7.90E+00	8.70E+00	8.90E+00	8.30E+00	7.50E+00	7.10E+00	6.20E+00	6.10E+00	7.30E+00	7.00E+00	7.10E+00
54 Mn	1.20E-02	9.00E-03	9.20E-03	1.10E-01	8.90E-03	1.20E-02	6.60E-03	7.50E-03	1.30E-02	2.30E-03	1.80E-03	2.00E-03	1.70E-03	3.10E-03
57 Co	3.80E-04	3.60E-04	/	2.90E-04	3.80E-04	3.90E-04	2.20E-04	2.80E-04	3.90E-04	7.30E-05	3.90E-05	8.20E-05	7.50E-05	9.50E-05
58 Co	1.40E-03	9.30E-04	2.30E-04	6.60E-04	7.10E-04	9.90E-04	4.00E-04	4.50E-04	8.10E-04	6.40E-05	6.90E-05	1.00E-04	1.40E-04	4.10E-04
60 Co	3.20E-01	3.00E-01	3.60E-01	3.80E-01	3.60E-01	2.60E-01	2.30E-01	2.10E-01	4.70E-01	1.20E-01	8.60E-02	6.10E-02	5.60E-02	8.30E-02
63 Ni	8.60E-02	6.80E-02	8.00E-02	5.30E-02	1.20E-01	3.90E-02	2.70E-02	6.20E-02	9.70E-02	6.40E-02	5.10E-02	3.50E-02	2.90E-02	1.80E-02
65 Zn	2.40E-04	1.20E-04	/	2.60E-05	3.40E-04	3.50E-05	3.20E-04	4.20E-05	/	/	/	/	/	/
89 Sr	3.20E-02	1.20E-02	/	/	/	/	/	/	/	/	/	/	/	/
90 SrY	1.70E+00	1.00E+00	7.10E-01	9.00E-01	1.00E+00	2.80E-01	9.90E-01	4.30E-01	2.40E-01	3.40E-01	2.00E-01	2.00E-01	1.70E-01	1.60E-01
95 ZrNb	/	/	/	/	/	/	/	/	/	/	/	/	/	/
99 Tc	4.30E-01	3.90E-01	2.50E-01	1.40E-01	1.80E-01	7.90E-02	6.00E-02	4.50E-02	6.10E-02	7.40E-02	5.20E-02	5.20E-02	2.00E-02	2.70E-01
103 Ru	/	/	/	/	/	/	/	/	/	/	/	/	/	/
106 RuRh	1.40E+01	2.10E+01	1.70E+01	1.10E+01	1.40E+01	1.30E+01	1.20E+01	9.60E+00	4.50E+00	6.70E+00	3.20E+00	2.10E+00	2.50E+00	2.40E+00
110 mAg	/	/	/	/	/	/	/	/	/	/	/	/	/	/
124 Sb	/	/	/	/	/	/	/	/	/	/	/	/	/	/
125 Sb	5.10E-01	3.50E-01	3.80E-01	5.10E-01	3.40E-01	1.60E-01	1.70E-01	9.60E-02	7.40E-02	3.80E-01	1.40E-01	1.20E-01	9.70E-02	5.40E-01
129 I	1.80E+00	1.40E+00	1.20E+00	1.30E+00	1.30E+00	1.40E+00	1.40E+00	1.30E+00	1.40E+00	1.00E+00	1.10E+00	1.40E+00	1.30E+00	1.30E+00
134 Cs	5.80E-02	4.70E-02	4.00E-02	6.50E-02	4.20E-02	6.40E-02	6.10E-02	6.10E-02	6.80E-02	7.50E-02	6.90E-02	7.50E-02	5.20E-02	3.10E-02
137 Cs	1.30E+00	8.70E-01	1.50E+00	9.60E-01	7.60E-01	7.90E-01	7.10E-01	6.20E-01	1.00E+00	1.10E+00	9.40E-01	9.80E-01	6.70E-01	4.80E-01
144 CePr	1.80E-03	1.80E-03	1.50E-05	1.60E-03	1.00E-03	1.60E-03	1.50E-03	1.10E-03	3.20E-03	1.50E-04	2.30E-04	9.70E-04	3.70E-04	1.00E-04
154 Eu	4.70E-04	8.30E-04	8.60E-04	6.00E-04	7.20E-04	7.10E-04	8.70E-04	1.60E-03	7.10E-04	5.60E-04	4.20E-04	1.20E-03	9.80E-04	2.20E-04
155 Eu	8.90E-05	1.90E-04	/	1.60E-04	1.20E-04	2.60E-04	2.80E-04	4.60E-04	1.80E-04	8.10E-05	6.50E-05	2.20E-04	1.50E-04	4.80E-05
238 Pu	1.20E-02	1.00E-02	8.30E-03	8.30E-03	4.80E-03	4.80E-03	4.20E-03	6.10E-03	5.00E-03	5.40E-03	4.80E-03	7.30E-03	6.00E-03	5.90E-03
239/240 Pu	4.00E-03	3.30E-03	3.40E-03	4.60E-03	2.20E-03	1.40E-03	1.10E-03	1.80E-03	1.40E-03	1.70E-03	1.30E-03	1.90E-03	1.50E-03	1.70E-03
241 Pu	2.20E-01	2.80E-01	2.10E-01	2.30E-01	1.50E-01	1.30E-01	1.10E-01	1.50E-01	1.20E-01	1.20E-01	1.00E-01	1.60E-01	1.30E-01	1.40E-01
241 Am	3.50E-03	7.30E-03	2.10E-02	1.40E-02	5.70E-03	2.50E-03	2.50E-03	3.00E-03	2.80E-03	2.70E-03	1.90E-03	3.20E-03	2.60E-03	1.70E-03
242 Cm	/	2.40E-05	1.60E-05	1.20E-05	1.70E-05	1.60E-05	1.70E-05	2.40E-05	3.50E-05	1.10E-05	7.10E-06	1.90E-05	9.60E-06	9.20E-06
244 Cm	1.20E-03	1.50E-03	2.20E-03	1.20E-03	1.00E-03	1.10E-03	1.70E-03	2.60E-03	1.50E-03	1.40E-03	9.10E-04	1.90E-03	1.50E-03	7.50E-04
Alpha total	4.00E-02	3.70E-02	5.10E-02	3.90E-02	2.30E-02	1.70E-02	2.20E-02	2.50E-02	2.10E-02	2.00E-02	1.30E-02	2.20E-02	2.30E-02	1.70E-03
Beta total	1.60E+01	2.10E+01	1.80E+01	1.30E+01	1.40E+01	1.30E+01	7.5E+00	7.5E+00	7.5E+00	6.60E+00	3.50E+00	3.30E+00	2.80E+00	2.30E-01

'/' means result below measure threshold

Detail of routine marine discharges over 1999-2012

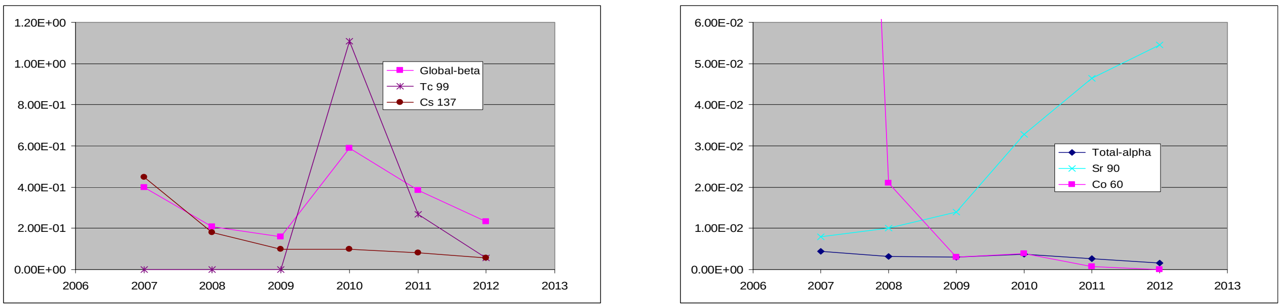


Evolution of the routine discharges of some nuclides between 1990 and 2012 (TBq)

2.3.2. Exceptional discharges

These discharges are caused by the so-called exceptional operations, related to decommissioning or retrieval and conditioning of legacy waste. They are reported every year to OSPAR in the table “Decommissioning” of the annual report. The scheme generally followed by the exceptional discharges starts when the operation that generates them begins, they reach a maximum, and come back to zero when the operation has come to an end. Several successive operations may appear.

Co 60 discharges were very high in 2007 (nearly 20 times the 2008 value) and have decreased since that time. Except for Sr 90 that has not reached its peak yet, the discharges of all nuclides have decreased between 2011 and 2012. In 2012, exceptional 99 Tc discharges still represent 67.16 % of the total 2012 99 Tc discharges, and exceptional 90 Sr discharges not decreasing yet represent 40.15 % of the total 2012 90 Sr discharges.



Evolution of the exceptional discharges between 2007 and 2012 (TBq)

Exceptional discharges often come from by-products that could not be sent to the distillation process in the evaporators and were sent to the less efficient chemical treatment. This is for instance the case of the draining of the head-end pools of the HAO. They presented a high 60 Co content but contained organic resins that could not withstand the evaporation temperatures. They were the cause of the 60 Co exceptional discharges that decreased in 2009 when the pools got empty. This is also the case of the by-products of the treatment of the used solvent stored in HADE that presented a high 99 Tc and other beta emitters content but contained organic solvent degradation products. They were the cause of the 99 Tc and beta emitters exceptional discharges that peaked in 2010.

2.3.3. Normalised data

As introduced above, routine discharge data have been normalised against the equivalent energy produced by the reprocessed fuel elements that represent the service rendered by this fuel. This method provides freedom from the variability due to the variations of the services rendered. The normalised data are proportional to the output/input ratio of radioactivity in the plant, i.e. its transfer factor to discharges (reciprocal of the decontamination factor). They thus characterise the global efficiency of the plant, comprising both the process efficiency and the abatement systems efficiency.

Normalised values against equivalent energy (in GW.y) for total alpha and total beta in routine marine discharges for the last two periods and back to 1995 are given in Appendix 2.

The global downward trends that can be observed during the past years show that the mastering of the processes and the facilities by the operator has been practically continuous and progressively going on, particularly for beta discharges. Alpha discharges seem to have reached an asymptote, at a very low level, the observed variability probably resulting from unavoidable operating discontinuities (start-ups, rinsing…).

2.4. Systems for quality assurance in relation to discharges

The Établissement AREVA NC de La Hague has an environmental management system that complies with the ISO 14001:2004 standard. This means that the environmental impact of the activities is systematically assessed and that there is a general commitment, including at the highest management level, to reduce the impact on the environment (See Appendix 4 for more details about the environmental management system).

The AREVA NC La Hague plants were renewed in 2013 (first obtained in 2005) the tri-certification for their activities of storage and nuclear fuel reprocessing, waste and recyclable product treatment and conditioning, flasks maintenance: ISO 9001:2008, ISO 14001:2004 and OHSAS 18001 (2007).

That is to say that, amongst other activities, the ones relative to the discharges are subject to a documented quality system ensuring a high degree of confidence in their results.

Certifications are subject to regular recertification processes and regulatory orders are under permanent inspection.

2.5. Site specific limit discharge values

The official authorisation limit values apply to the whole site. They are shown in table below for the 2003 and 2007 orders.

Discharges to the sea TBq/y	2003 Order	2007 Order
Tritium 3H	18 500	18 500
Iodines	2.6	2.6
14 Carbon	42	42
90 Strontium (1)	12	11
137 Caesium (1)	8	8
134 Caesium	2	0.5
106 Ruthenium	15	15
60 Cobalt (1)	1.5	1.4
Other $\beta-\gamma$ emitters (1)	60	60
Alpha emitters (1)	0.17	0.14

Specific limits are prescribed for the discharges from the so-called exceptional operations – those caused by final cessation of operation and dismantling (MAD/DEM) and reconditioning of legacy waste (RCD). Displayed values include routine and exceptional discharges, split as follows in the 2003 Order (modifications of the 2007 Order between brackets):

- 90 Strontium: 2 TBq/y for routine discharges, 10 TBq/y for exceptional operations (1.2 / 9.8),
- 137 Caesium: 2 TBq/y for routine discharges, 6 TBq/y for exceptional operations,
- 60 Cobalt: 1 TBq/y for routine discharges, 0.5 TBq/y for exceptional operations (0.9 / 0.5),
- Other [illegible] emitters: 30 TBq/y for routine discharges, 30 TBq/y for exceptional operations,
- Alpha emitters: 0.1 TBq/y for routine discharges, 0.07 TBq/y for exceptional operations (0.07 / 0.07).

Authorization limits of marine discharges set by the
January 10th 2003 and January 8th 2007 ministerial orders

The 2007 order features reductions for routine discharges of 40 % for 90 Strontium, 75 % for 134 Caesium, 10 % for 60 Cobalt and 30 % for alpha emitters.

2.6. Description of on-going or planned activities

Regarding exceptional operations, the ministerial order of January 10th 2003, completed by the January 8th 2007 order, sets separate bounds for routine discharges from exceptional operations namely final cessation of operation and dismantling of former facilities or retrieval and conditioning of legacy waste.

Regarding waste treatment, the best practice nowadays is to promote direct waste conditioning in-line with the treatment. This allows the sorting out at the source, an easier traceability, the transfer of surface storage compatible waste towards the existing disposal facilities and the local safe storage of other wastes.

Historically, conditioning of waste generated by the first spent fuel reprocessing operations has been delayed, considering the technologies unavailability and the required time to develop conditioning processes, set up storing systems and lay out investments.

These wastes have been stored safely in silos or pits, waiting to be retrieved and definitively conditioned.

The planning of the retrieval and conditioning of legacy wastes involves:

- Retrieval of sludges (generated by coprecipitation) from the STE2 effluent treatment plant, which should start around 2016 and scheduled to end before 2030, significant actions being already carried out since 2001 (research and development programs, inactive and active tests),
- Retrieval of metallic structural waste from spent fuel processed in UP2-HAO, planned to start around 2019 and to end around 2028.
- Retrieval of structural waste of magnesium and graphite type resulting from the processing of metallic uranium fuel in UP2-400, in two successive phases (concerning two distinct facilities), planned to end before 2030.

During the period, several pilot campaigns of STE2 sludge conditioning have been performed from different tanks filled at different periods, in order to qualify the equipment and the processes of retrieval, transfer and characterisation of the sludges. A substitute to the bitumen conditioning has been developed since 2005 (drying of the sludges and compacting in order to substantially reduce the volume of solid waste in view of a future storage). The process and the final conditioning as planned are under the process of a regulatory authorization.

Some operations have generated specific by-products in the period. They are as much as possible applied the same abatement techniques as those used for the routine discharges. This is the case for practically all the rinsing operations of the equipment performed in the MAU, MAPu, HA and PF workshop prior to their MAD/DEM quoted in § 1.3, as well as the MAD/DEM operations of the HAO workshop since 2009. Taking into account the efficiency of these techniques, most of these operations generated practically no discharges. Only those by-products that could not, because of their physical or chemical composition, be sent to distillation have been treated by the co-precipitation process in STE3 and generated discharges.

The operations that generated most of the discharges in the period are:

- the retrieval and conditioning of the solvent used in the UP2 plant before 1990 and stored in vessels of the PF workshop, accounting for the greatest part of the discharges, particularly Tc 99 discharges;
- the draining and cleaning of the HAO working pools, accounting for the major part of Co 60 discharges.

These operations have generated discharges representing a detectable but relatively small part of the authorization pertaining to these operations.

2.7. Summary evaluation for discharges

Table below summarizes the evaluation concerning BAT/BEP indicators of the site-specific information on discharges from the AREVA NC La Hague site.

Criteria	Evaluation
The BAT/BEP indicators	
Relevant systems in place	Yes, Management and technical systems improved since the start of the plants
Abatement factor	High factors
Downward trend in discharges	Constant or downwards
Downward trend in normalized discharges	Mainly downwards
Comparison with UNSCEAR data	No available comparative UNSCEAR data
Relevant and reliable quality assurance	Yes
Relevant site specific discharge values	Yes
Data completeness	Complete
Causes for deviations from indicators	None
Uncertainties	No influence on the conclusions
Other information	R&D for other improvements in progress

Summary Evaluation for Discharges

3. ENVIRONMENTAL IMPACT

3.1. Concentration of radionuclides of concern in environmental samples

A pluralistic committee of international experts, the GRNC (Groupe Radioécologie Nord-Cotentin), comprising stakeholders such as local associations or non-governmental organisations, has been created in 1997 by the ministers in charge of the environment and health with the mission to assess the total impact of the nuclear facilities of the North-Cotentin on the potentially most exposed populations as well as the associated risks.

Sampling of grass

The GRNC has grounded its work on the results of some 80,000 analyses a year carried out from around 25,000 samples, taken in different places and media. The GRNC analysed more than 500,000 results and its Report [1] gives many detailed figures on this subject.

The reported elements come from the regulatory registers, sent monthly to the ASN. Monthly regulatory registers indicate the activities asked for in the order, for various bio-indicators such as ground, grass, vegetation, milk, fruits, vegetables, meat for terrestrial compartment and coastal and deep sea water, sand, sediments, seaweeds, limpets and fishes for the marine compartment. The summary of these measurements can be found in the annual report of environment monitoring which is required by the § d) of the 32nd article of the 8th January 2007 ministerial order that complements the January 10th 2003 ministerial order.

Annual mean concentrations in coastal waters, fucus, limpets and fishes are given in Appendix 3, for 1995 and 2004 to 2012.

Sampling of seawater

A comprehensive assessment of marine biota doses [2] was conducted in 2003 by an environmental-expert consulting firm, SENES, managed by recognized Canadian experts. Key results show that the radiation dose rates to marine biota arising from the AREVA NC La Hague facilities were at that time at least 2-3 orders of magnitude lower than the lowest guidance values for the protection of the populations of marine biota (UNSCEAR, IAEA) and at least 1-2 orders of magnitude lower than those from the background radiation in the region.

The consensus appraisal of this study by a group of international experts came to the major conclusion that “the predicted dose rates to marine biota attributable to the radioactive discharges to the sea from the AREVA NC La Hague facilities are small, and in general, well below the comparison guidance levels at which deleterious and observable effects to populations of marine biota might, according to current knowledge, be expected”.

3.2. Environmental monitoring program

The detailed environmental monitoring program is established every year and communicated to the ASN in consistency with the ministerial order. Types of measurements, frequencies and associated sampling and analysis methods are defined in the January 10th 2003 ministerial order, completed by the January 8th 2007 ministerial order. The 2008 monitoring program has been published in full in the 2010 edition of the present report. Since there are only minor modifications from one year to the other, it has not been published again in the present edition, the reader will be able to consult it in the former edition [5] that is available on the OSPAR web site under the reference p00503.

Delayed monitoring is performed in different environmental compartments. About 20,000 samples are taken every year, leading to nearly 50,000 analyses every year. Samples are taken in every compartment of the environment participating in the potential pathways of the radionuclides to man: marine, terrestrial and hydrogeologic compartments. Feedback from experience helps to choose the place and number of measurement points guaranteeing that the whole process is thoroughly mastered.

The results of the program allow assessing permanently the real impact of the AREVA NC La Hague site on the environment.

- Marine monitoring is an important part of monitoring. It is performed through discontinued measurements with time-shifted analysis. It ranges from Granville to the Bay of river Seine (near Le Havre). The sampling in the marine component comprises coastal samples (sand, seaweeds and limpets), deep sea samples (water, sediments), flat and round fishes, scallop shells, crabs, oysters, mussels, lobsters.
- Terrestrial monitoring is performed on rainwater, vegetation, milk and other foods, which are regularly sampled and analysed.
- Hydrologic monitoring includes drinking waters, small streams and the ground waters, to verify hydrologic and hydrogeologic dispersion.

Sampling is performed by AREVA NC employees, except for the off-shore sampling in the high sea, which is performed by the French Navy.

Some independent complementary sampling is performed by the IRSN's LRC (Cherbourg-Octeville Radioecological Laboratory) that has extensively studied the water movements in the North Sea, using 125 Sb discharged by the AREVA NC La Hague site as a quite perfectly conservative tracer during sampling campaigns in 1986 and 1994. Conversely, the result of these studies is used to determine the dilution of the AREVA NC La Hague site effluents in the sea, in view of the impact assessments.

The sampling and measurements performed by the LRC for R&D purpose complement those performed by the IRSN on behalf of the ASN.

The North Cotentin Radio Ecology Group too has made an important use of the LRC results in its independent first assessment of the AREVA NC La Hague site impact.

COGEMA's then AREVA NC's monitoring results have been compared with the LRC measurements every year until 2006 within the context of the GRNC impact assessment required by the January 10th 2003 ministerial order. The advice resulting from this assessment for 2006, last year considered by this request that has not been kept in the 2007 ministerial order, has been presented in the 2010 edition of the present report [5] that is available on the OSPAR web site.

3.3. Systems for quality assurance of environmental monitoring

The Environmental Laboratory activity, as part of the activities of the AREVA NC Établissement de La Hague, complies with the ISO 14001 environmental standard, as included in the jointed certifications ISO 14001:2004, ISO 9001:2008 and OHSAS 18001 (2007) obtained in 2005 and renewed in 2013. Concerning the analyses and measures of fresh and waste waters for alpha, beta, gamma, tritium and 90 strontium, and sea water for beta and gamma, the COFRAC accreditation (French national accreditation organism) has been renewed in 2013 (first obtained in 1996), as meeting the requirements of the ISO 17025 (2005) standard. This accreditation, delivered by an independent organism, results from the assessment of the quality system and of the management of analysis methods in term of adequacy of materials, equipments used and staff qualification.

This involves regular calibration of detectors with secondary standards traceable to primary standards and intercomparison exercises with other laboratories, both national and international, such as the one of the IAEA. (In addition to the regulatory intercomparisons with IRSN). The intercomparison tests consist in the measurement of a sample by about fifty laboratories and the comparison of the results by the test organizer.

The AREVA NC laboratory participates to ISO standards working-out.

The laboratory has been granted the ministerial agreement for the measurement of a certain number of radionuclides in the environment, in accordance with articles R. 1333-11 and R. 1333-11-1 of the public health regulations. Most of these agreements, for those related to the marine environment, can be seen in the marine environment monitoring program presented in the Appendix 5 of the 2010 edition of the present report [5].

The ASN requires that the operators follow a program of cross measurements, aimed at guarantying the quality of the results of the analysis performed by the operators. The operator has to provide samples of the discharged effluents to a laboratory that has been agreed by the ASN. Some of these samples are analysed according to a program defined by the ASN. The operator has to check the consistency of the results of these measurements with those that it has himself obtained. L'Établissement AREVA NC de La Hague has selected for this cross measurements the laboratories of the environment and intervention directorate of the IRSN.

3.4. Summary evaluation of environmental impact

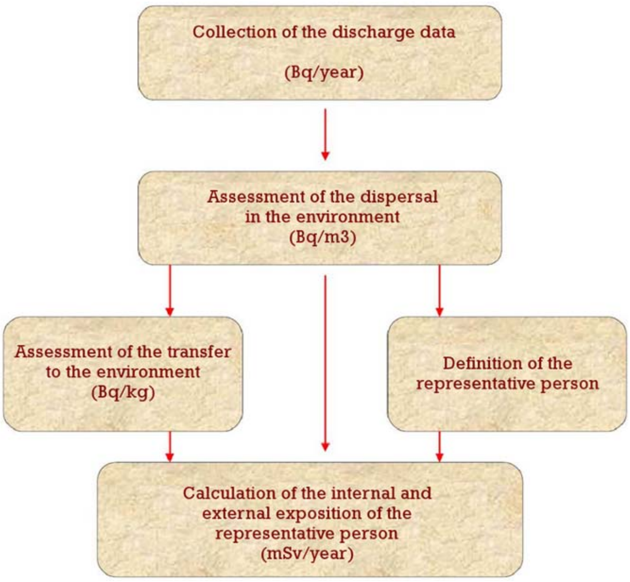
Table below summarizes the evaluation concerning BAT/BEP indicators of the site-specific information on Environmental Impact from the AREVA NC La Hague site.

Criteria	Evaluation
The BAT/BEP indicators	
Downward trends in concentrations	Yes
Relevant environmental programme	Yes
Relevant quality assurance programme	Yes
Data completeness	Yes
Causes for deviations from indicators	No deviations
Uncertainties	Low because many samples
Other information	None

Summary Evaluation for the Environmental Impact

4. RADIATION DOSES TO THE PUBLIC

4.1. Average annual effective doses



The principle of the impact assessment

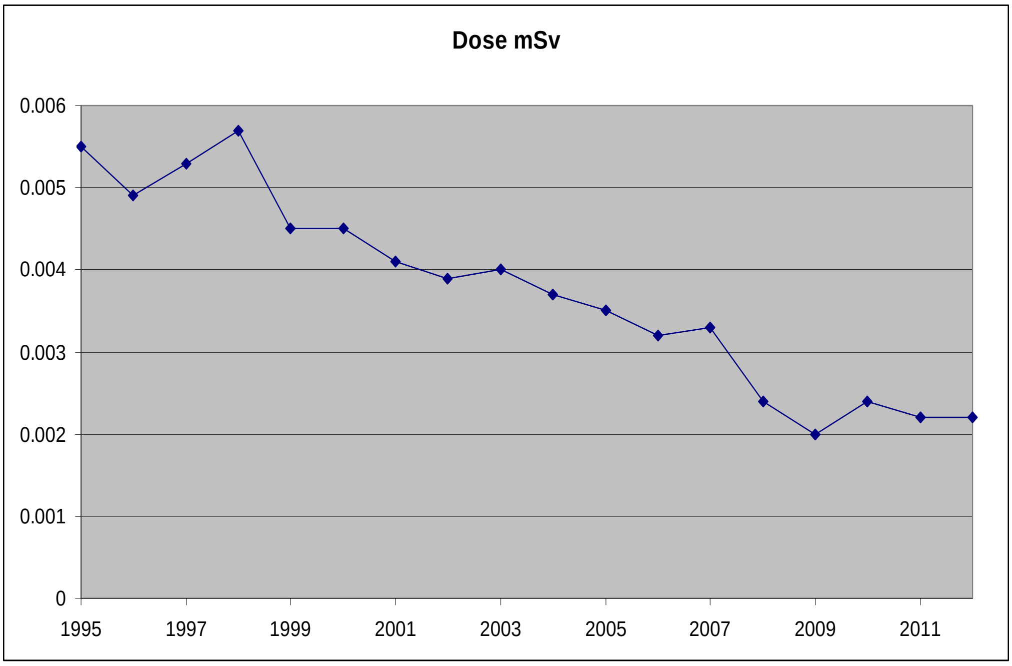
An impact assessment method has been derived from the GRNC method, and a software named ACADIE (Internal and External Dose Calculation Application) has been developed jointly by the IRSN, the ASN and AREVA NC, based on the work of the GRNC and agreed by this committee.

Operator discharge values have been used in the impact assessment. La Hague area specific parameters for dietary and living habits, derived from inquiries or specific studies performed within the context of the 1998 impact study, have been implemented in the ACADIE software. ACADIE is used to assess the impact of annual discharges. This assessment has been until 2006 submitted to the GRNC appraisal, through the 32nd article of the January 10th 2003 ministerial order.

Annual effective doses computed with the latest version of ACADIE on the representative person for marine discharges are shown in table below:

Year	Dose (mSv)
1995	0.0055
1996	0.0049
1997	0.0053
1998	0.0057
1999	0.0045
2000	0.0045
2001	0.0041
2002	0.0040
2003	0.0040
2004	0.0037
2005	0.0035
2006	0.0032
2007	0.0033
2008	0.0024
2009	0.0020
2010	0.0024
2011	0.0022
2012	0.0022

Evaluation performed with the ACADIE software of the doses to the representative person of the Goury fishermen related to marine discharges during the 1995-2012 period



Evolution of the annual dose to the representative person of the Goury fishermen from 1995 to 2012

For the marine pathway related impact to the Goury fishermen representative person, it can be seen that the doses resulting from the total actual discharges since 1995 have significantly decreased and have always stayed more than two orders of magnitude below the dose limit of 1 mSv set by the French regulations (April 04th 2002 decree setting the limit of dose added by nuclear activity for the public).

Analysis confirms that the dose caused by tritium is negligible besides the one resulting from the other radionuclides (< 1 %).

The impact of the exceptional discharges on the period is low, at most a little less than 5 % of the total impact in 2010, much less for the other years of the period.

4.2. Total exposures

The other sources of exposure can be found in publications [3][3]. The main one in this region is the inhalation of radon emitted by the granitic bedrock. IRSN studies consider that the average exposure estimated from mean values of measured radon concentrations indoor and outdoor in Cotentin is 1.9 mSv/y. Telluric exposure (from natural nuclides in the ground) is estimated at 0.35 mSv/y, and exposure due to cosmic rays at 0.28 mSv/y. Specific local measurements of 210 Po[4] made by the IRSN in 1990-1994 have been carried out in sea food. The recorded concentrations, with the selected diets, lead to an exposure due to the ingestion of natural nuclides of 3.04 mSv/y for the Goury fishermen. It has indeed to be noted that the ingestion of mussels or other shells, moderate but above the average, can very easily bring this value above 1 mSv/y (regulatory limit for the dose added by nuclear activities to the public), only through the natural 210 Po they contain. This is the case for the Goury fishermen. Internal self-exposure due to natural 40 K can be estimated at 0.17 mSv/y, and due to 14 C, mainly of natural origin, to 0.012 mSv/y. No local estimation figure could be found for the exposure due to medical care, but the French average of 1.3 mSv/y (INRS 2012) can be retained. The values are summarized in table below.

mSv/y	Goury fishermen
Radon inhalation	1.90
Telluric origin	0.35
Cosmic rays	0.28
Ingestion natural nuclides	3.04
Self-exposure 40K	0.17
Self exposure 14C	0.012
Medical exposure	1.3
TOTAL	7.05

Exposure to the representative person of the Goury fishermen, all sources except nuclear facilities

The total values are above France average (around 3.7 mSv/y in 2012 according to IRSN) due to the nature of the ground that generates direct external exposure and indirect internal exposure through the inhalation of the radon it generates, and particularly because of the local diet which brings above the average quantities of 210 Po in the seafood.

Nuclear facilities in the vicinity of the representative person of the AREVA NC La Hague site bring very little exposure to this one: the surface disposal centre for low activity wastes of ANDRA is estimated to bring around 0.000,35 mSv/y (all paths considered) to its own representative person in 2012 [4]. The nuclear power plant pair of Flamanville brought around 0.000,24 mSv/y through its liquid discharges on its own representative person in 2012 [6]. The conservative summing up of these values[5] would bring 0.000,69 mSv/y, that is to say it adds 0.010 % to the exposure of the representative person of the Goury fishermen that is submitted to 7.05 mSv/y from other sources.

The addition of the exposure due to the 2006 global dose (atmospheric and marine) of the AREVA NC La Hague site, conservatively assessed by the GRNC in its 4th mission at 0.007 mSv for the more penalizing representative person, brings only another 0.099 % to the preceding total.

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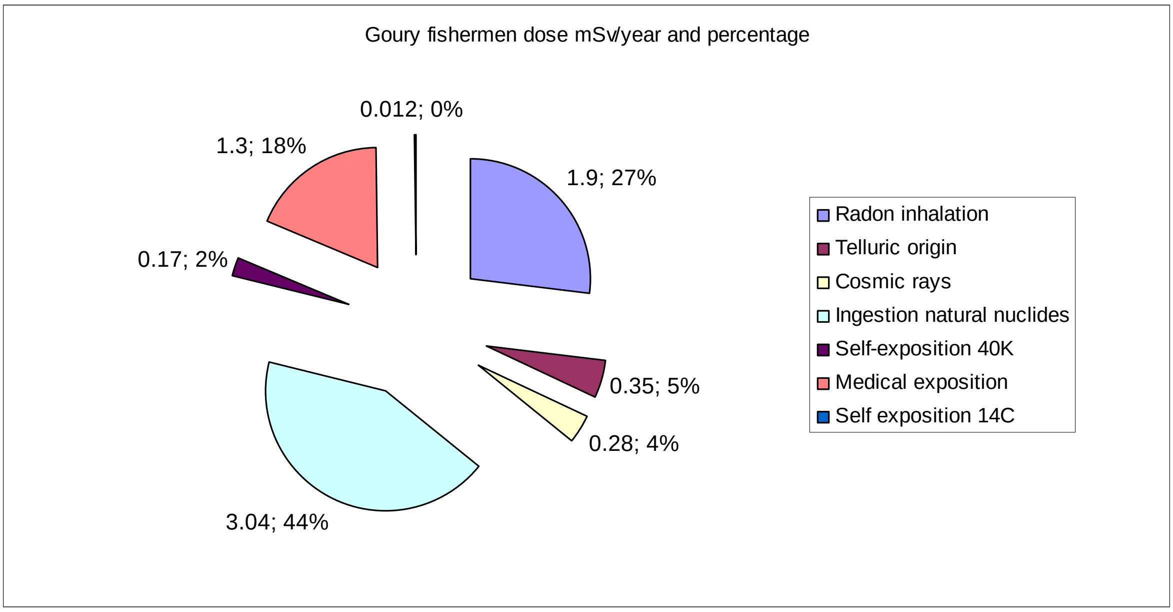
4 The results of these measures do not prejudge the origin of such 210 Po.

5 The representative persons of the three quoted sites (AREVA NC La Hague, EDF Flamanville and ANDRA Disposal Centre) being different, with different locations, none of these representative persons is exposed to the sum of the doses assessed for each of these persons. Any kind of summing up of the doses relative to different representative persons leads to a value higher than the actual one.



Breakdown of the exposure to the representative person of the Goury fishermen, all sources except nuclear facilities

The influence of all neighbouring nuclear facilities, including the AREVA NC La Hague site, estimated in a conservative way by summing all the values at 0.007,81 mSv/y is then 0.12 % of the exposure due to other sources. The additional value of 0.007,81 mSv/y is much below the dose limit of 1 mSv set by the French regulations (April 04th 2002 decree setting the limit for the dose added by nuclear activity for the public).

4.3. The definition of the representative person

The process of definition of the representative person follows ICRP Recommendation 101 of 2006. This Recommendation states that the *representative person* is an individual receiving a dose that is representative of the more highly exposed individuals in the population through their usual domestic, occupational or leisure activities[6].

A group of experts committed by the French Ministry in charge of the health [7] has recommended in 1996 to chose, among real groups of persons, those which can be used as a reference (farms, villages and towns), all impact pathways having to be taken into account. This recommendation excludes purely hypothetical groups.

The representative person relative to the marine pathway is a member of the Goury fishermen group. Fishermen have the longer lasting contact with the sea and its sprays and their consumption of seafood is proved to be above the average one. The small village of Goury, almost at the tip of the Cap de la Hague, was identified as the coastal point where radionuclides concentrations are the highest (two times lower at Barfleur, east of Goury on the north coast, three times lower at Blainville, south of Goury on the west coast).

It is assumed, in a conservative way, that all the seafood of local origin ingested by the representative person used to live in the concentrations encountered in the vicinity of Goury.

4.4. The information on exposure pathways considered

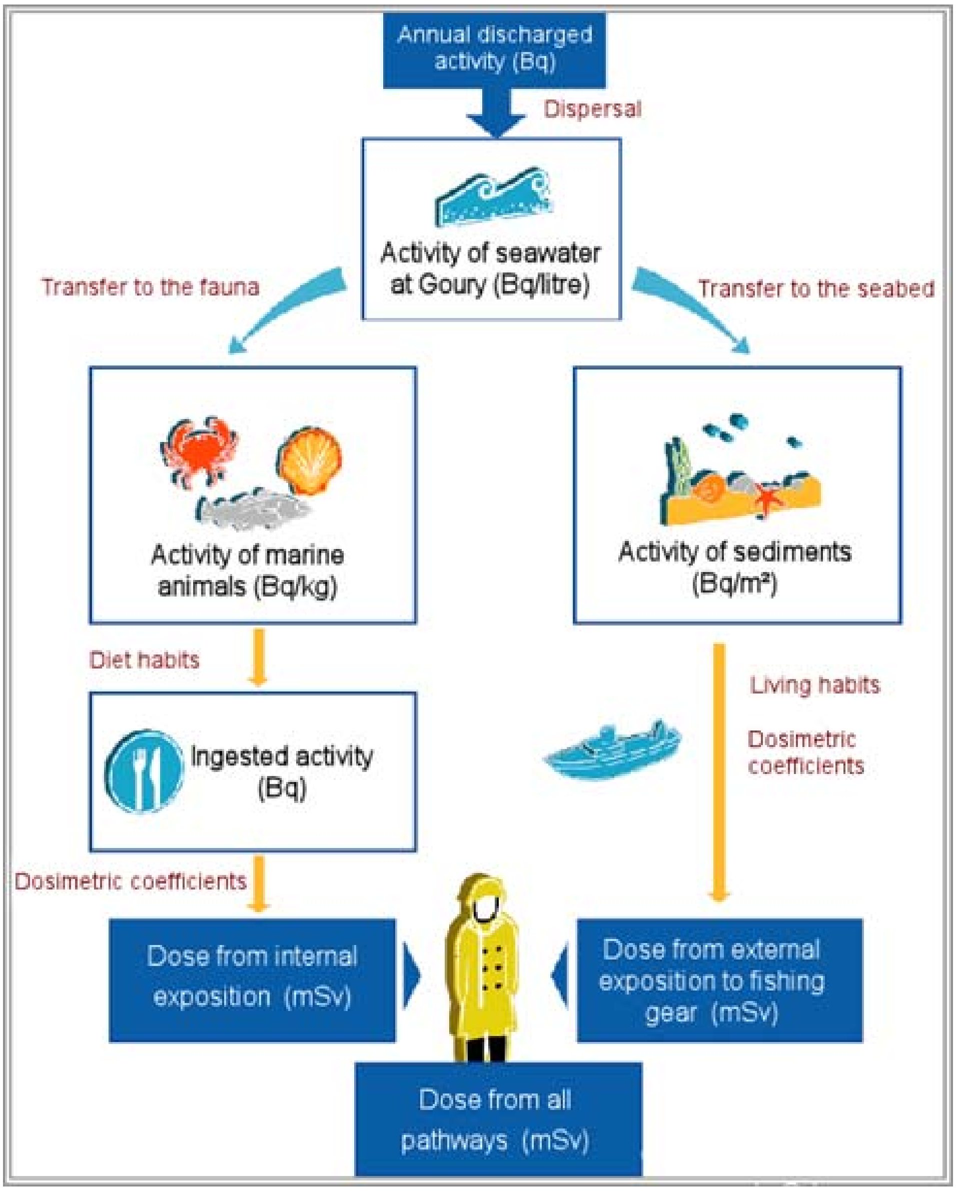
The discharged effluents disperse into the environment. Transfer to man comes through two compartments of the biosphere, the terrestrial compartment (through atmospheric discharges), and the marine compartment. In the marine compartment, most of the nuclides are released in a soluble form, but some of them can form

6 The term representative person is the equivalent of, and replaces, the average person of the reference group described in EURATOM Directive 96/29.

colloids, polymers, or be adsorbed on solid particles. Nuclides are more or less assimilated by marine species, function of the metabolism of the species itself, and of the chemical and physical properties of the nuclide.

Pathways to man from radioactive elements in the marine environment include the ingestion of seafood and external exposure, which depends on the local habits. For the general population, only leisure activities on the beaches have to be considered. The contamination of soil and shore vegetation resulting from the spray of seawater, which can be observed in bioindicators such as gorse is light and does not constitute a significant pathway to man.

The contribution of external exposure, whatever the activity, is much lower than the contribution of the ingestion of seafood.



The exposure pathways for liquid discharges

4.5. *Basis for methodology to estimate doses*

Since 2003, methodology (modelling) is that of the GRNC, defined during its first mission about the 'Estimation of exposure levels to ionizing radiation and associated risks of leukaemia for populations in the Nord Cotentin' (July 2000 report) [7], later finalised as the ACADIE software.

Specific parameters entering the model are drawn from dedicated studies, such as local diet and living habits inquiries or concentrations monitoring campaigns.

Dispersion factors in the sea are derived from initial experiments with buoys and tracers, and from many measures performed during nearly 50 years, in particular by the IRSN, interpreted and validated by the work of the GRNC.

Concerning the external exposure of fishermen, exposure time has been conservatively taken at 7 hours a day, 365 days a year [8].

The diet has been defined from the enquiry made by the CREDOC, in April-May 1998, in four zones over Cap de La Hague, Cherbourg city area, West and North coast, Centre, and East coast [8]. Seafood diet of the marine representative person is conservatively taken as the one of the 95th percentile, that is to say the one of the 5 % of people having the highest consumption of seafood. Total annual sea food consumption is taken at about 127 kg, of which more than 70 kg are from local origin (supposed to live precisely in Goury waters); the rest of the food represents about 236 kg of which more than 67 kg are from local origin.

Concentration factors in fauna and sediments are taken from measurement results (IRSN/LRC experimental campaigns) interpreted by the GRNC [1] to define the coefficients, when measurable, and from EU publication (1979) for others, 14 C for instance.

Corrective factors have been affected to the transfer factors to the marine compartment by the GRNC experts in order to take into account the actual results of measurement in the environment (more than 500,000 results used).

External exposure factors are taken from the September 1st 2003 ministerial order for krypton, and Federal Guidance 12 from US-EPA for other radionuclides.

Whole body dose coefficients for inhalation and ingestion are also taken from this same order, which is the transposition to French law of EURATOM Directive 96/29.

More details on ACADIE are given in Appendix 5.

4.6. Site specific factors for significant nuclides

Site-specific factors are presented above.

4.7. Site specific target annual effective dose

French regulations do not consider targets for the annual effective dose. The limits apply only to the discharges. Nevertheless, the effective doses to the representative persons are assessed every year.

4.8. Systems for quality assurance of processes involved in dose estimates

As any other activity of the Établissement, the processes involved in dose assessment comply with the ISO 9001:2008 quality standards, as part of the jointed certification of integrated management ISO 14001:2004, ISO 9001:2008 and OHSAS 18001 (2007). That is to say, in particular, that they are traceable and subject to verifications. Independent verifications are performed by the technical support of the ASN, IRSN. The initial work of the GRNC [1], as ordered by the government, constitutes also a very extensive verification of all the work performed relative to the discharges, including the dose assessment.

4.9. Summary evaluation of radiation doses to the public

Table below summarizes the evaluation concerning the BAT/BEP indicators of the site-specific information on radiation doses to the public from the AREVA NC La Hague site.

The methods for estimating the doses, agreed by the GRNC and the IRSN, are relevant for judging the exposure of the population and to check the compliance with the dose limits and constraints. The doses are decreasing due to managerial and technical improvements continuously implemented on the AREVA NC La Hague site.

Criteria	Evaluation
The BAT/BEP indicators	
Downward trend in radiation dose	Yes
Relevant critical group	Yes
Reliable dose estimates	Yes
Relevance of target dose	No target dose for the site
Relevant quality assurance systems	Yes
Data completeness	Data are complete
Causes for deviations from indicators	No deviations
Uncertainties	Low
Other information	Assessment method based on the work of the GRNC, pluralistic expert group

Summary Evaluation for Radiation Doses to the Public

5. SUMMARY – BAT

From the evaluations of the BAT/BEP indicators for discharges, environmental impact and radiation doses to the public it is concluded that the BAT have been applied at the AREVA NC La Hague site during the time period covered by this report as well as before.

6. ADDITIONAL INFORMATION

One of the main goals of the AREVA NC La Hague plants operators has always been to control the discharges and their impact, aiming at an industrial activity without any harm, neither for the workers nor for the population. Since the creation of the site, the operators keep continuously investing in the evolution of the industrial units, in order to integrate progress achieved in processes, technologies and impacts knowledge. This is clearly apparent in the evolution of the doses to the workers, of the waste volume production and of the discharges that have been continuously decreasing since the beginning of operation and are still decreasing. The impact to the representative person is low and the efforts are nevertheless still going on.

It should not be forgotten, however, that as new improvements are implemented, the expected impact gains will get lower and lower and the corresponding expenses will have to be evaluated in regard to the prevention costs usually accepted against all the domestic, industrial, technological and dietary risks to which the population is exposed, in a consistent way with the ICRP statement: ("If the next step of reducing the detriment can be achieved only with a deployment of resources that is seriously out of line with the consequent reduction, it is not in the society's interest to take that step, provided that individuals have been adequately protected." according to ICRP Publication 21 - 1973).

This point being recalled, several directions of progress are envisaged. Those concerning liquid effluents are exposed hereafter.

In addition to the process improvements already in use in UP3-A and UP2-800 (including the R4 workshop), the preferred orientation of liquid effluents towards vitrification, by concentrating them, will continue to be extended in the following years to the effluents resulting from the shutdown and the decommissioning programs of the UP2-400 plant, in consistency with the constant research of the Best Available Techniques for these operations.

6.1. R&D

In the framework of the Article 42 of the ministerial order of January 8th 2007, about forty options effectively leading to a reduction of the impact[7] of the radioactive discharges to the sea have been examined (these options are not necessarily exclusive from one another, their effects cannot be added up)[8].

The total cost of the corresponding R&D work amounted to nearly 5 million Euros within a 6 years period (2006-2001).

The option that leads to the greatest reduction of the impact (near 30 % mainly by reducing simultaneously 129 I and 14 C discharges) is based on the Voloxydation/Oreox process. It would require for each of the two La Hague plants the installation of a whole workshop between the shearing and the dissolution units when these units are closely interlocked inside the same high activity contaminated cell. Each new workshop would comprise two 10 metre long calcinators, working at 400-500 °C that would represent a major safety threat. Moreover, there are absolutely no safe and qualified conditioning and disposal processes for the by-products of this process, neither for 129 I nor for 14 C. Knowing that:

- This process needs more R&D before being industrially implemented;
- There is practically no room around the head-ends of the La Hague plants to build such workshops;
- The energy consumption of these workshops would increase the energy balance of the site by 7 %;

It is clear that the implementation of this option cannot be envisaged on the La Hague site.

The three next options relate to a reduction of 14 C discharges and would lead to a 15-16 % (each, non cumulative) reduction of the impact. They are more or less easy to implement, but they suffer the major drawback that there is absolutely no safe and qualified conditioning and disposal process for their by-products.

The problem is the same for the next two ones, very similar but for 129 I, that would lead to a nearly 13 % (each, non cumulative) reduction of the impact, with the same drawback of the lack of a qualified conditioning and disposal process.

Only these 6 options lead to a reduction of impact that is higher than 5 %.

The two next options (7th and 8th) relate to the treatment of the alkaline effluents concentrates (CEB), that could lead to a 4.5 % (each, non cumulative) reduction of the impact.

It has to be noted that the anticipated gain relies mainly on the reduction of 106 Ru discharges (99.55 %). The gain does not take into account the practical operating dispositions that already allow a reduction of the 106 Ru discharges, simply by using the available buffer storages as decay storages, leading to a 106 Ru cooling time before discharge of much more than the nominal 8 years before processing. The 4.5 % value is then more theoretical than realistic.

The first of these two options has been dealt with in the preceding report. It consists in the vitrification of the CEB in their entirety. The process has needed extensive R&D to prevent foaming of the solutions and clogging of the equipment, a solution has been found that requires more R&D to allow for an industrial rate, and because it uses a nickel compound that is in the scope of REACH measures. The work and the industrial tests are going on.

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7 The total impact and the relative reductions are determined for a reference industrial scenario of 1,500 tons heavy metal processed by year, with an initial enrichment of 3.9 % in 235 U, a burn-up of 48 GW.d/tU and a cooling time of 8 years before processing. The corresponding reference impact from the total discharges to the representative person that is more particularly subjected to the impact of the discharges to the sea (Goury fisherman) is 8.55 µSv/year.

8 Details about some of these options have been given in the preceding edition of this report.

The second one is the grouting of the entirety of the CEB. This option would require the installation of a new grouting unit of relatively high capacity (430 m^3/year), of a buffer storage unit for this production that would increase the site production of grouted waste by 46 %. This option is not consistent with the first point of the definition of BAT in the OSPAR Convention, which says that "In seeking the best available techniques, emphasis is placed on the use of technologies that do not produce wastes, if such are available." The constraints and cost of this option lead to make it less favourable than the preceding one.

The next option (9th) relates to the discharges of 60 Co and would lead to a nearly 4 % reduction of the impact. It consists in the evaporation of the effluents of the transportation casks maintenance workshop (AEC) and of the water treatment of the NPH storage pond. Cobalt comes from the oxidised surface of the fuel elements, is deposited in the transportation casks and in the storage ponds. Ponds other than NPH (C, D and E ponds) have a different water treatment that does not lead to the same 60 Co discharges. The option would require the installation of new evaporation capacities and buffer storage tanks in very irradiating areas. This would lead to high exposures for the setting up and increased exposure for the operation. This puts at a disadvantage this option that would otherwise be acceptable.

The next option (10th) relates to the discharges of alpha emitters and would lead to a 3.7 % reduction of the impact. It consists in an ionic exchange on the effluents of STE V and in the vitrification of the elution by-product. The ionic exchanger has to be periodically changed and the used one has to be grouted. The size of the equipment must be adapted to the high flow, and its removal and disposal would be a serious safety constraint.

The next option (11th) consists in improving the process of the liquid effluents treatment unit STE3. It has been dealt with in the preceding report. It would lead to a 3.16 % reduction of the impact, mainly based on 106 Ru discharge reduction (99.97 %). In the same way as for options 7th and 8th, this reduction is purely theoretical, since it does not take into account the practical reductions brought by practical operating measures. This option is relatively simple to implement. The flow is reduced (the lesser quantity of by-products allows for this), the location of the introduction of the reagents is improved and the quantity of reagents is increased up to the theoretical maximum. Its drawbacks are the cost of the increased reagent consumption and the increase in solid waste volume. Industrial tests are going on in order to lessen the variability of the results.

All other options have a potential gain in impact reduction lower than 3 % (for 6 of them) and lower than 1 % (for the remaining ones). The gain for these options can be considered lower than the variability of the discharges and prevents further examination.

The result of this extensive R&D work strengthens the conclusion that the present processes and implementation represent the Best Available Techniques for the discharges to the sea of the AREVA NC La Hague site.

6.2. Tritium discharges

Regarding tritium, in accordance with the BAT philosophy, a periodic review of the processes that could be used to reduce the tritium discharges to the sea is performed. Their nominal impact is already only 0.28 % of the total nominal impact. To complement the option that was quoted in the preceding report, 8 options have been examined, with a potential gain of 0.14 % on the impact, except for the use of the Voloxydation/Oreox process that would lead to a 0.21 % gain. But it has been seen concerning 129 I and 14 C that this option was not practicable on the La Hague site.

Three options are based on the grouting of the tritiated effluents, one on the raw effluents, one after concentration by the TRILEX process and one after concentration by isotopic separation of the tritium. These three options, that are not consistent with the first BAT principle of no increase in solid waste, have to be discarded because of the lack of a qualified conditioning and disposal process of the grouted waste.

The four remaining ones are based on discharge after a 12 years decay of the tritium, preceded by more or less concentration that requires more equipment, but less decay storage. These four options create a very strong safety constraint: the smallest atmospheric leak from the storage would generate an impact much more important than the anticipated gain, all the more than the concentration is higher.

The first option does not require any process equipment but stores the raw by-products in a 240,000 m^3 storage, quite unrealistic by the surface it would need and its cost.

The second one relies on the TRILEX patents and concentrates the by-product in such a way that the storage would be reduced to a nevertheless hardly realistic 144,000 m^3, with the complementary constraint of more equipment and a subsequent much larger tritiated zone in the plant.

The third one uses a costly complex isotopic separation process to concentrate the effluents so that the necessary storage is reduced to 960 m^3, which is nevertheless difficult to install and it keeps the drawbacks of the second one.

The fourth one is an improvement of the third one, where the isotopic separation process treats the by-product of a new fission products concentration unit and a new tritiated acid recovery unit, both more efficient, so that the storage volume could be reduced to 500 m^3.The size and complexity, hence the cost, of the two complementary new units make this option more unrealistic than the preceding one.

This survey shows that the physical dispersion and isotopic dilution to the sea of the tritiated effluents of the AREVA NC La Hague site is still today the Best Available Technique.

6.3. Conclusion

The impact to the marine pathway representative person is already at levels considered by the radiological protection specialists as being insignificant from the radiological aspect. Considering that the objective of an industrial activity is to perform without any harm, neither to the workers nor to the population, we consider it as reached for the AREVA La Hague Facility. Then we make allowance for the principle of the ICRP publication 21 (as already quoted above in § 6: "If the next step of reducing the detriment can be achieved only with a deployment of resources that is seriously out of line with the consequent reduction, it is not in the society's interest to take that step, provided that individuals have been adequately protected.") before envisaging any new progress of the process.

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Appendix 1: System(s) in place to reduce, prevent or eliminate discharges and their efficiency

Abatement system/ Management	Into operation (Year)		Efficiency of abatement system		Comments
	Existing	Planned	Decontamination Factor DF or purification factor FE[9]	Other measure of efficiency	
Recycling:					
Acidic washing of hulls and end-pieces	1990			100 %	After distillation
Water washing of hulls and end-pieces	1990			100 %	After distillation
Water washing of vitrified waste canisters				100 %	After distillation
Water washing of compacted waste canisters				Around 50 %	Function of operating conditions
Condensates from vacuum generation				100 %	After distillation
Recovered tritiated acid	1990			100 %	After distillation
Recovered non-tritiated acid	1990			100 %	After distillation
Recovered solvent	1990			100 %	After distillation, liquid concentrate is grouted
Distillation:					
Acidic effluents	1996		FE=10^3 à 10^5		Distillates discharged to the sea, concentrates vitrified
Alkaline effluents	1996		FE=10^4		Distillates discharged to the sea, chemical precipitation of concentrates before discharge
Recovered tritiated acid	1990		FE=10^3 à 10^5		
Recovered non-tritiated acid	1990		FE=10^3 à 10^5		
Oxalic mother liquors	1990		FE=10^6 à 10^7		
Process improvements:					
Continuous monitoring of the pH of precipitation process	1987		FD for α=400 β=4 125 Sb=1,1 106 Ru=4 137 Cs=100 90 Sr=5		STE3 with separate reactors
Separate reactors for the introduction of each reagent	1987				STE3
Use of stoichometric reagent concentrations in the chemical effluent treatment	2008				STE3

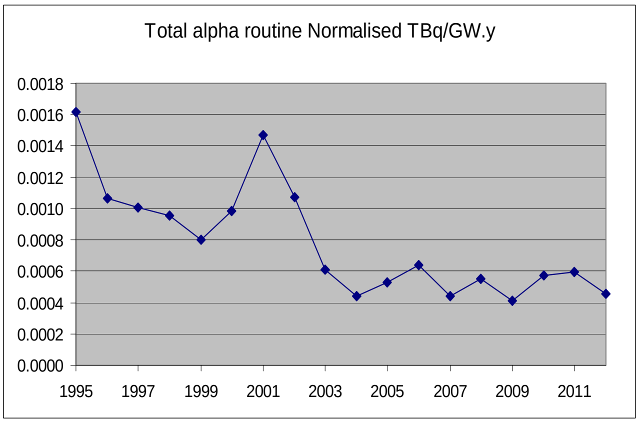
[9] Decontamination factor FD= Activity flow of the feed divided by activity flow of the distillate
Purification factor FE= Specific activity of the concentrate divided by specific activity of the distillate.

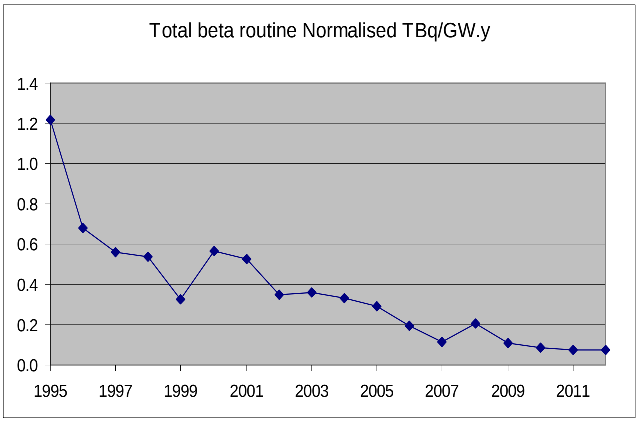
Abatement system/ Management	Into operation (Year)		Efficiency of abatement system		Comments
Use of pulsed columns in place of mixers-settlers	1990				UP3-A first and second separation cycles
Use of centrifugal extractors in place of mixers-settlers	2002				R4 plutonium purification
Optimisation of the solvent path in the whole process	1990				UP3-A
Reinforcement of 99 Tc washing	1998			FD increased 4 to 5 times	UP3-A
Change of analysis methods	2000				Laboratory, with no reagent preventing the distillation
Replacement of laboratory analysis by on-line continuous measurement requiring no sampling	2000			100 %	UP3-A, UP2-800
Installation of a Pu recovery unit on the laboratory effluents	2000				UP3-A, UP2-800
Finer adjustment of STE3 process regarding 137Cs removal	2003		?	?	
ultrafiltration	1990		α=600 β=1.5		Laboratory effluents
vitrification		2009-2010	106Ru=2		Integration of alkaline effluent concentrates in vitrified waste
Use of over stoichiometric concentrations of reagents in the chemical decontamination process of STE 3	2009		Increased decontamination factor		Eliminates most of the discharges of type A effluents at the cost of a few more solid waste drums.
Radioactive decay:					
Fuel elements are “cooled” in storage pools during an average period of 5 years after extraction from reactor core before processing	1990			Radioactive decay of 106Ru	DF=32 for 5 years delay
Fission products solution cannot be processed for vitrification before 6 years after extraction from reactor core	1990			Radioactive decay of 106Ru	DF=64 for 6 year delay (does not cumulate with preceding one)

Appendix 2: Normalised routine marine discharges since 1995

TBq/y	Equiv. Energy GW.y	Total alpha routine		Total beta routine	
		Absolute	Normalised / GW.y	Absolute	Normalised / GW.y
1995	43.45	7.01E-02	1.61E-03	5.29E+01	1.22E+00
1996	43.14	4.61E-02	1.07E-03	2.94E+01	6.82E-01
1997	47.49	4.77E-02	1.00E-03	2.66E+01	5.60E-01
1998	49.36	4.72E-02	9.56E-04	2.65E+01	5.37E-01
1999	49.19	3.95E-02	8.03E-04	1.59E+01	3.23E-01
2000	37.19	3.67E-02	9.87E-04	2.10E+01	5.65E-01
2001	34.64	5.09E-02	1.47E-03	1.83E+01	5.28E-01
2002	36.64	3.92E-02	1.07E-03	1.28E+01	3.49E-01
2003	37.5	2.30E-02	6.13E-04	1.36E+01	3.63E-01
2004	39.25	1.74E-02	4.43E-04	1.31E+01	3.34E-01
2005	41.43	2.2E-02	5.31E-04	1.2E+01	2.90E-01
2006	38.97	2.5E-02	6.42E-04	7.5E+00	1.92E-01
2007*	38.25	1.69E-02	4.42E-04	4.4E+00	1.15E-01
2008	31.31	1.72E-02	5.49E-04	6.37E+00	2.03E-01
2009	32.3	1.32E-02	4.09E-04	3.54E+00	1.10E-01
2010	38.6	2.20E-02	5.70E-04	3.35E+00	8.68E-02
2011	39.1	2.32E-02	5.93E-04	2.85E+00	7.29E-02
2012	39.3	1.8E-02	4.58E-04	2.81E+00	7.15E-02

*2007 values take into account exceptional discharges that have not been reported separately to OSPAR in 2007.





Appendix 3: Annual mean concentrations of nuclides in the marine environment over the 2004-2012 period

The table is complemented by the 1995 values as a reference.

Coastal waters (Bq/l)	1995	2004	2005	2006	2007	2008	2009	2010	2011	2012
125 Sb	< 0.11	< 1.20	< 0.74	< 0.75	< 0.81	< 0.79	< 0.45	< 0.40	< 0.40	< 0.46
106 Ru	< 0.32	< 4.40	< 5.31	< 5.45	< 5.70	< 5.74	< 3.20	< 2.80	< 2.80	< 3.30
137 Cs	< 0.04	< 0.53	< 0.33	< 0.33	< 0.35	< 0.34	< 0.19	< 0.17	< 0.17	< 0.20
60 Co	< 0.06	< 0.67	< 0.40	< 0.41	< 0.42	< 0.42	< 0.24	< 0.20	< 0.21	< 0.24
239/40 Pu	< 3.76E-05	< 5.75E-05	< 7.51E-05	< 5.91E-05	< 7.10E-05	< 6.44E-05	< 2.90E-05	< 2.50E-05	< 3.00E-05	< 2.80E-05
238 Pu	< 5.27E-05	< 6.53E-05	< 7.55E-05	< 3.89E-05	< 5.50E-05	< 3.63E-05	< 1.90E-05	< 2.30E-05	< 2.60E-05	< 2.50E-05
Potassium 40	12.5	12.7	13.0	12.3	13.0	12.5	13.0	12.0	13.0	12.0
Beta activity	13.8	-	11.4	12.6	13.0	12.6	13.0	12.0	13.0	13.0
3 H	-	< 14.60	< 12.70	< 9.55	< 9.50	< 8.05	< 6.30	< 9.40	< 9.60	< 9.90

Fucus (Bq/kg fresh)	1995	2004	2005	2006	2007	2008	2009	2010	2011	2012
125 Sb	< 0.40	< 0.25	< 0.25	< 0.24	< 0.25	< 0.24	< 0.12	< 0.11	< 0.13	< 0.13
137 Cs	< 0.22	< 0.12	< 0.12	< 0.11	< 0.12	< 0.12	< 0.07	< 0.06	< 0.08	< 0.07
129 I	-	7.25	7.00	5.36	6.50	5.25	4.40	4.90	5.50	7.50
131 I	-	-		-	-	-	-	-	-	-
60 Co	2.43	< 0.37	< 0.35	< 0.29	< 0.67	< 0.42	< 0.26	< 0.19	< 0.17	< 0.14
106 Ru	< 1.66	< 1.04	< 2.10	< 2.10	< 2.30	< 1.94	< 0.99	< 0.91	< 1.10	< 1.10
241 Am	< 0.35	< 0.13	< 0.13	< 0.13	< 0.13	< 0.12	< 6.20E-02	< 6.00E-02	< 6.60E-02	< 6.80E-02
239/40 Pu	< 0.06	< 0.07	< 0.06	< 0.06	< 0.05	< 0.05	< 3.80E-02	< 4.10E-02	< 4.60E-02	< 3.70E-02
238 Pu	< 0.06	< 0.07	< 4.70E-02	< 3.90E-02	< 5.10E-02	< 4.20E-02	< 2.40E-02	< 2.40E-02	< 3.30E-02	< 2.80E-02
Potassium 40	257	289	290	266	280	299	280	280	270	270
14 C	-	32,.0	35.0	36.9	38.0	39.0	36.0	32.0	31.0	34.0

* natural and artificial

- result of analysis not available< result below measurement threshold

Limpets (Bq/kg fresh)	1995	2004	2005	2006	2007	2008	2009	2010	2011	2012
125 Sb	< 0.17	< 0.34	< 0.34	< 0.34	< 0.36	< 0.35	< 0.17	< 0.18	< 0.20	< 0.20
110 mAg	< 0.48	-	-	-	-	-	-	-	-	-
137 Cs	< 0.10	< 0.16	< 0.16	< 0.16	< 0.16	< 0.16	< 0.08	< 0.08	< 0.09	< 0.09
129 I	-	< 0.33	< 0.31	< 0.26	< 0.31	< 0.24	< 0.26	< 0.28	< 0.35	< 0.47
60 Co	0.77	< 0.22	< 0.21	< 0.21	< 0.26	< 0.23	< 0.12	< 0.13	< 0.12	< 0.12
106 Ru	< 1.20	< 1.35	< 3.00	< 2.65	< 2.90	< 2.70	< 1.40	< 1.40	< 1.60	< 1.50
241 Am	< 0.39	< 0.13	< 0.14	< 0.14	< 0.14	< 0.13	< 6.90E-02	< 6.80E-02	< 8.00E-02	< 8.00E-02
239/40 Pu	< 0.03	< 0.02	< 0.02	< 0.03	< 0.02	< 2.30E-02	< 2.10E-02	< 1.40E-02	< 1.50E-02	1.40E-02
238 Pu	< 0.030	< 0.020	< 0.015	< 0.02	< 1.40E-02	< 1.30E-02	< 1.00E-02	< 7.50E-03	< 9.80E-03	< 7.80E-03
Potassium 40	60.9	70.5	72.0	68.7	73.0	78.0	100.0	100.0	100.0	92.0
14 C*	-	54.0	59.0	58.1	61.0	60.0	56.0	50.0	55.0	56.0

Fishes (Bq/kg fresh)	1995	2004	2005	2006	2007	2008	2009	2010	2011	2012
125 Sb	< 0.14	< 0.27	< 0.27	< 0.29	< 0.28	< 0.29	< 0.15	< 0.14	< 0.14	< 0.15
137 Cs	< 0.45	< 0.19	< 0.24	< 0.19	< 0.17	< 0.17	< 0.14	< 0.12	< 0.15	< 0.14
129 I	-	< 0.11	< 0.11	< 0.11	< 0.10	< 0.10	< 0.07	< 0.09	< 0.06	< 0.06
60 Co	< 0.08	< 0.16	< 0.16	< 0.17	< 0.16	< 0.17	< 0.09	< 0.08	< 0.08	< 0.09
106 Ru	< 0.44	< 1.01	< 1.99	< 2.21	< 2.11	< 2.22	< 1.05	< 1.10	< 1.05	< 1.10
241 Am	-	< 0.11	< 0.11	< 0.12	< 0.10	< 0.11	< 5.15E-02	< 5.15E-02	< 5.20E-02	< 5.50E-02
239/40 Pu	-	< 1.00E-02	< 1.10E-02	< 1.00E-02	< 1.00E-02	< 1.00E-02	< 5.85E-03	< 6.05E-03	< 5.20E-03	< 5.35E-03
238 Pu	-	< 1.00E-02	< 1.40E-02	< 1.20E-02	< 1.20E-02	< 1.00E-02	< 5.00E-03	< 7.45E-03	< 5.00E-03	< 4.40E-03
Potassium 40	97.3	107.0	109.0	110.0	120.0	124.0	125.0	125.0	110.0	115.0
14 C*	-	39.8	39.0	46.0	41.0	47.0	39.5	37.0	32.5	34.5

* natural and artificial

- result of analysis not available< result below measurement threshold

Appendix 4: the environmental management system of the Établissement AREVA NC de La Hague

The ISO 14001:2004 Standard

This international standard defines the arrangements to be implemented by an organisation, in order for this one to manage the impact on the environment of its activities and products. The implementation of this standard brings to external stakeholders (authorities, representatives, inhabitants, communities, etc.) of the organisation confidence in:

- Its commitment to respect its policy;
- The implementation of preventive rather than corrective actions;
- The conformity to legal and regulatory requirements;
- A process of continuous improvement of the significant environmental impacts.

The environmental management system

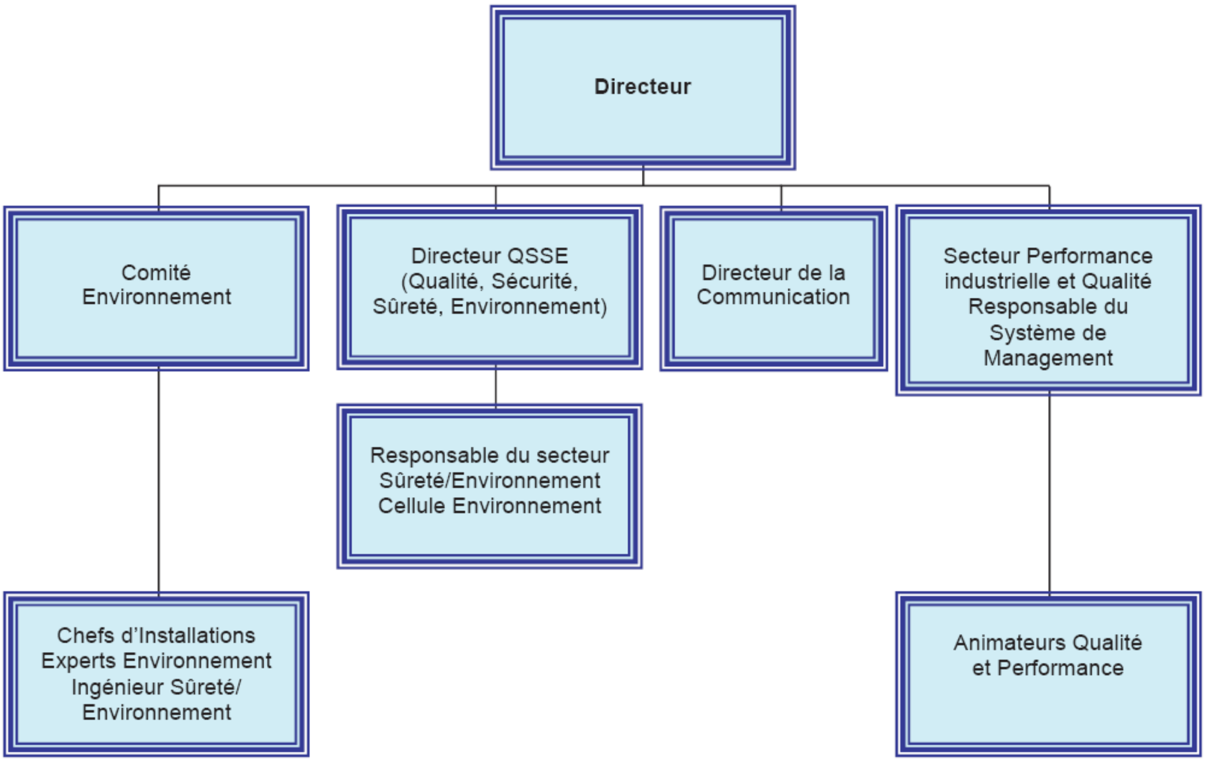
Perimeter

The environmental management system is implemented in compliance with the ISO 14001:2004 Standard.

It applies to all the activities controlled by the Établissement AREVA NC de La Hague that may have an environmental impact, that is to say the treatment of nuclear fuel and nuclear substances, the recycling activities and the associated activities on the AREVA site of La Hague.

The geographical perimeter is defined by the limits of ownership of the facility, to which are associated the five measurement stations in neighbouring villages and all the piezometers that are managed by the facility.

The environmental organisation



- A decisional structure, the Environment Committee.

  It defines the axis for improvements, validates the program of environmental management, follows the progression of the actions and examines the environmental indicators.

- An operational structure

  It is the Nuclear Safety – Environment sector, in which an Environment Section is specifically in charge of animating the environment management system.

- Relays on the field

  Environmental experts: they update the environmental analysis of their competence, propose improvement actions and give an advice on the modifications.

  Managers of sections: they stimulate the workers of their sector, manage the follow up of the action of the Environmental Management Program and update the environmental indicators of their sector.

  Safety/Environment Engineers and their Manager: they assess the environmental impact of the modifications.

  Environmental auditors: they perform the internal audits required by the Environmental Management System.

The selected themes

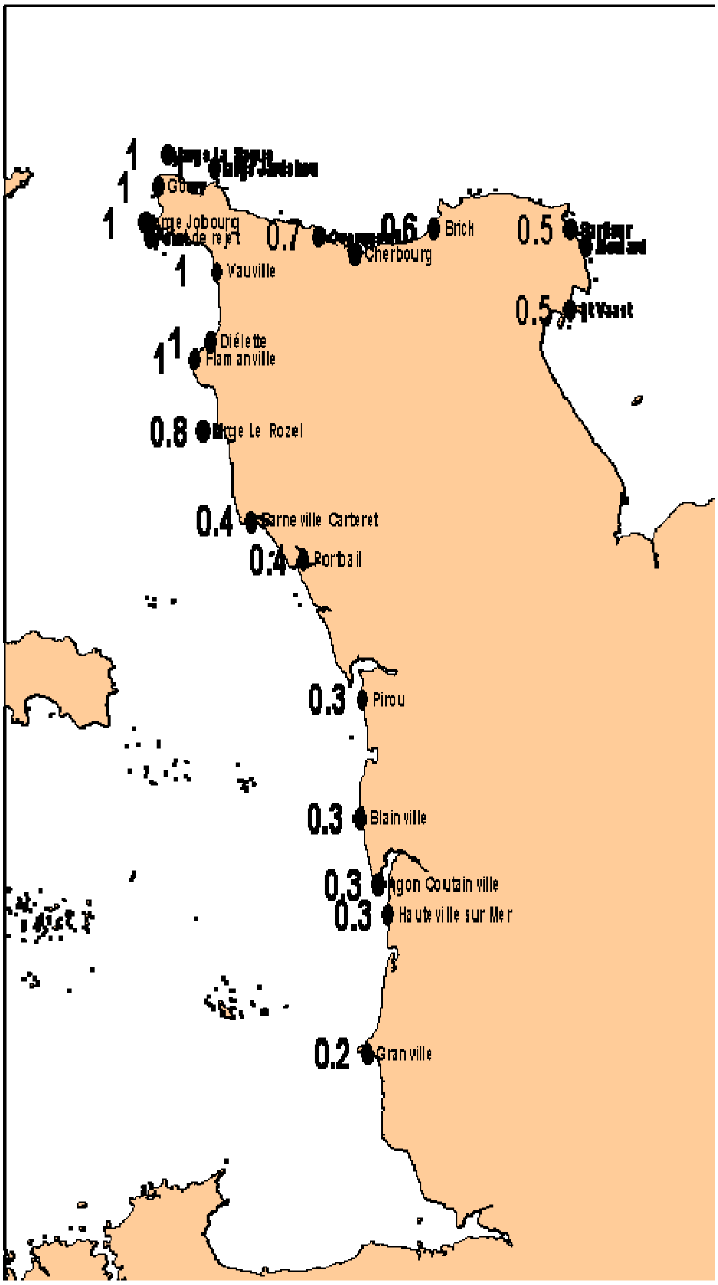
- Atmospheric discharges of non-nuclear facilities
- Atmospheric discharges of nuclear facilities
- Chemical pollution of ground and subsoil
- Conventional waste
- Energy management
- Liquid discharges in streams
- Liquid discharges of nuclear facilities
- Nuisances and biodiversity
- Radioactive pollution of ground and subsoil
- Reagents and chemical products
- Solid nuclear waste
- Transport of nuclear substances
- Water management

Appendix 5: ACADIE impact assessment model

I - Dispersion

Dispersion of liquid effluents discharged to the sea can be modelled by dilution factors. These dilution factors are ratios averaged on the year scale of the measured activity of the sea water, from which the background level is derived, to the flow of radioactivity discharged by the considered facility. The GRNC has assessed dilution factors from activity measurement results that have been obtained on a large time scale and for different sampling points. A hydrodynamic model of residual currents has also been used.

The selected dilution factors are indicated on the map below. They are expressed in relative value to the dilution factor assessed by the IRSN for Goury (selected representative person for the impact of the discharges to the sea of the AREVA NC La Hague facility).



Dilution factors of the discharges of the AREVA NC La Hague reprocessing plants
Reference value (unit at Goury) correspond to 0.76 $Bq.m^{-3}$ for 1 TBq discharged per year.

II - The transfer in the various compartments of the marine environment

The activity of the sea water in the different coastal sectors of the North-Cotentin is computed from the dilution factors as defined above and the activities of the various radionuclides annually discharged under liquid form by the reprocessing plant of AREVA NC La Hague, following formula below:

$$A\ sea\ water = Fd \times Q$$

With:

A sea water:	activity of the sea water ($Bq.m^{-3}$)
Fd:	dilution factor ($Bq.m^{-3}$/Bq discharged.y^{-1})
Q:	discharge rate (Bq discharged.y^{-1})

It is possible to estimate the activity content of marine species (algae, fishes, shellfishes and molluscs) and sediments on the basis of a steady state at year's scale. In a steady state, the mass specific activity of living species and sediments is supposed to be proportional to the volumetric activity of the sea water at the place where they are sampled.

Corresponding proportionality factors are named concentration factors (FC) for marine species and distribution factors (Kd) for the sediments. The assumption of proportionality implies that a balance is obtained between the different compartments of the medium (algae, marine species and sediments). When this condition is not reached, the measured radioactivity of marine species is different from the one computed using the FCs and Kds. The GRNC has compared the model and the measurement results for the indicators and the radionuclides for which measures were available spread over a long time. In some cases, corrective factors have been integrated into the model of the transfer to the environment.

The values of the corrective factors are shown in Appendix I to this document, those of the concentration factors in Appendix II and those of the distribution coefficients in Appendix III.

III – Marine species

Six indicators have been selected:

- Algae (a);
- Fishes (f);
- Crustaceans (c);
- Filtering molluscs (m1);
- Non-filtering molluscs (m2);
- Sediments.

The activity of marine species is calculated from the following formula:

$$A\ (a,f,c,m1,m2) = A\ sea\ water \times FC\ (a,f,c,m1,m2) \times 0.001 \times Fcorrect.$$

With:

A (a,f,c,m1,m2):	activity in the algae, fishes, crustaceans and molluscs ($Bq.kg^{-1}$ fresh),
A sea water:	activity in the sea water ($Bq.m^{-3}$),
FC (a,f,c,m1,m2):	concentration factor for algae, fishes, crustaceans and molluscs ($l.kg^{-1}$ fresh),
0.001:	conversion factor,
Fcorrect.:	corrective factor (dimensionless).

The GRNC has selected the concentration factors recommended by the IRSN for living species, because they reflect more particularly the behaviour of the radionuclides in the species living in the English Channel. When there was no IRSN value, the GRNC has selected the IAEA values.

For some radionuclides, there is no concentration factor value available. The concentration factors of the chemical analogs have been selected. Thus beryllium has been taken as cobalt, rubidium as caesium, rhodium as ruthenium and praseodymium as cerium.

IV – Sediments

The activity of the sediments is calculated from the following formula:

$$A\ sed = A\ seawater \times Kd \times 0.001 \times Fcorrect$$

With:

A sed: activity in the sediments ($Bq.kg^{-1}$ dry)
A seawater: activity in seawater ($Bq.m^{-3}$)
Kd: distribution coefficient ($l.kg^{-1}$ dry)
0.001: conversion factor
Fcorrect: corrective factor (dimensionless)

For 244 Cm, the Kd value selected by the GRNC was the value set forth by the IAEA, i.e. 2,000,000 l/kg dry [2]. In February 2002, IRSN has published the results of a study on the behaviour of radionuclides in the environment [3]. One of the conclusions of this study is that the Kd of 244 Cm in the considered sediments is lower than the one selected by the GRNC (by a factor of 100); adequate value is around 20,000 l/kg dry. GRNC has selected this new value and an assessment of the hazards associated to 244 Cm has been performed [4].

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[4] Ringeard C., Réexamen des risques associés aux rejets de Cm-244 dans les effluents liquides de l'usine COGEMA La Hague et à l'ingestion de sable par les enfants de 0 à 2 ans – Réponse à la saisine DSSQ-2002-37 de COGEMA en date du 4 février 2002, Fiche Technique 02/22-bis, Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-aux-Roses, 2002.

APPENDIX I.-. CORRECTIVE FACTORS

	Algae		Fishes		Crustaceans		Filtering molluscs		Non-filtering molluscs		Sediments	
	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->
3H	1	1	1	1	1	1	1	1	1	1	1	1
10Be	0.6	1.1	0.8	2	0.5	1.3	0.5	2	0.5	1.2	0.04	0.04
14C	1	1	1	1	1	1	1	1	1	1	1	1
36Cl	1	1	1	1	1	1	1	1	1	1	1	1
41Ca	1	1	1	1	1	1	1	1	1	1	1	1
54Mn	1.1	1.1	1	1	1	1	1	1	1	1	1	1
55Fe	1	1	1	1	1	1	1	1	1	1	1	1
57Co	1	1	0.8	2	0.5	1.3	0.5	2	1	1	0.04	0.04
58Co	0.7	0.7	0.8	2	0.5	1.3	0.5	2	0.5	0.5	0.04	0.04
60Co	0.6	1.1	0.8	2	0.5	1.3	0.5	2	0.5	1.2	0.04	0.04
59Ni	1	1	1	1	1	1	1	1	1	1	1	1
63Ni	1	1	1	1	1	1	1	1	1	1	1	1
65Zn	9	9	1	1	1	1	1	1	0.35	0.35	1	1
75Se	1	1	1	1	1	1	1	1	1	1	1	1
79Se	1	1	1	1	1	1	1	1	1	1	1	1
87Rb	0.7	0.7	0.2	0.2	0.4	0.4	0.5	0.5	0.6	0.6	0.2	0.2
89Sr	0.4	0.4	0.6	1.2	1.3	1.3	1	1	0.4	0.4	3	3
90Sr	0.4	0.4	0.6	1.2	1.3	1.3	1	1	0.4	0.4	3	3
91Y	1	1	1	1	1	1	1	1	1	1	1	1
93Zr	1	1	1	1	1	1	1	1	1	1	1	1
95Zr+Nb	1	1	1	1	1	1	1	1	1	1	1	1
94Nb	1	1	1	1	1	1	1	1	1	1	1	1
93Mo	1	1	1	1	1	1	1	1	1	1	1	1
99Tc	1.9	1.9	1	1	1	1	1	1	1	1	1	1
103Ru	0.7	0.7	3.9	3.9	0.5	0.5	0.2	1	0.4	0.4	0.05	0.2
106Ru	0.7	0.7	3.9	3.9	0.5	0.5	0.2	1	0.4	0.4	0.05	0.2
107Pd	1	1	1	1	1	1	1	1	1	1	1	1
110mAg	1	1	1	1	1	1	1	1	1	1	1	1
113mCd	1	1	1	1	1	1	1	1	1	1	1	1

	Algae		Fishes		Crustaceans		Filtering molluscs		Non-filtering molluscs		Sediments	
	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->
121Sn	1	1	1	1	1	1	1	1	1	1	1	1
121mSn	1	1	1	1	1	1	1	1	1	1	1	1
126Sn	1	1	1	1	1	1	1	1	1	1	1	1
124Sb	0.9	0.9	3.8	3.8	1.4	1.4	0.5	0.5	1.2	1.2	0.2	0.6
125Sb	0.9	0.9	3.8	3.8	1.4	1.4	0.5	0.5	1.2	1.2	0.2	0.6
126Sb	0.9	0.9	3.8	3.8	1.4	1.4	0.5	0.5	1.2	1.2	0.2	0.6
127Te	1	1	1	1	1	1	1	1	1	1	1	1
127mTe	1	1	1	1	1	1	1	1	1	1	1	1
129I	1	1	1	1	1	1	1	1	1	1	1	1
131I	1	1	1	1	1	1	1	1	1	1	1	1
134Cs	0.7	0.7	0.2	0.2	0.4	0.4	0.5	0.5	3.4	3.4	0.2	0.2
135Cs	0.7	0.7	0.2	0.2	0.4	0.4	0.5	0.5	1	1	0.2	0.2
137Cs	0.7	0.7	0.2	0.2	0.4	0.4	0.5	0.5	0.6	0.6	0.2	0.2
144Ce	0.5	0.5	1	1	1	1	1	1	3.1	3.1	1	1
147Pm	1	1	1	1	1	1	1	1	1	1	1	1
151Sm	1	1	1	1	1	1	1	1	1	1	1	1
152Eu	1	1	1	1	1	1	1	1	1	1	1	1
154Eu	1	1	1	1	1	1	1	1	1	1	1	1
155Eu	1	1	1	1	1	1	1	1	1	1	1	1
232U	1	1	1	1	1	1	1	1	1	1	1	1
233U	1	1	1	1	1	1	1	1	1	1	1	1
234U	1	1	1	1	1	1	1	1	1	1	1	1
235U	1	1	1	1	1	1	1	1	1	1	1	1
236U	1	1	1	1	1	1	1	1	1	1	1	1
238U	1	1	1	1	1	1	1	1	1	1	1	1
237Np	1	1	1	1	1	1	1	1	1	1	1	1
236Pu	1	1	1	1	1	1	1	1	0.6	0.6	1	1
238Pu	1	1	1	1	1	1	1	1	0.6	0.6	1	1
239,240Pu	1	1	1	1	1	1	1	1	0.6	0.6	1	1
241Pu	1	1	1	1	1	1	1	1	0	0	1	1
242Pu	1	1	1	1	1	1	1	1	0	0	1	1
241Am	1	1	1	1	1	1	1	1	1	1	1	1

	Algae		Fishes		Crustaceans		Filtering molluscs		Non-filtering molluscs		Sediments	
	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->	FC ->90	FC 91->
242Am	1	1	1	1	1	1	1	1	1	1	1	1
242mAm	1	1	1	1	1	1	1	1	1	1	1	1
243Am	1	1	1	1	1	1	1	1	1	1	1	1
242Cm	1	1	1	1	1	1	1	1	1	1	1	1
243Cm	1	1	1	1	1	1	1	1	1	1	1	1
244Cm	1	1	1	1	1	1	1	1	1	1	1	1
245Cm	1	1	1	1	1	1	1	1	1	1	1	1
246Cm	1	1	1	1	1	1	1	1	1	1	1	1
133I	1	1	1	1	1	1	1	1	1	1	1	1

APPENDIX II.-. CONCENTRATION FACTORS

	Algae	FC (l.kg^{-1} fresh)
H	Tritium	1
C	Carbon	5,000
I	Iodine	10,000
Ru	Ruthenium	300
Sb	Antimony	20
Sr	Strontium	40
Cs	Caesium	50
Co	Cobalt	6,000
Tc	Technetium	30,000
Pu	Plutonium	4,000
Am	Americium	400
Cm	Curium	400
Mn	Manganese	5,000
Ag	Silver	5,000
Fe	Iron	20,000
Mo	Molybdenum	100
Ce	Cerium	5,000
Zn	Zinc	2,000
Zr	Zirconium	2,000
Cl	Chlorine	0.05
Ca	Calcium	6
Ni	Nickel	2,000
Eu	Europium	3,000
Se	Selenium	1,000
Np	Neptunium	50
Y	Yttrium	1,000
Nb	Niobium	3,000
Pa	Palladium	100
Cd	Cadmium	5,000
Sn	Tin	20,000
Te	Tellurium	10,000
Pm	Promethium	3,000
U	Uranium	100
Be	Beryllium	
Rb	Rubidium	
Sa	Samarium	3,000
Pr	Praseodymium	

	Fishes	FC ($l.kg^{-1}$ fresh)
H	Tritium	1
C	Carbon	5,000
I	Iodine	15
Ru	Ruthenium	2
Sb	Antimony	20
Sr	Strontium	5
Cs	Caesium	400
Co	Cobalt	200
Tc	Technetium	80
Pu	Plutonium	100
Am	Americium	100
Cm	Curium	100
Mn	Manganese	1,000
Ag	Silver	4,000
Fe	Iron	1,000
Mo	Molybdenum	20
Ce	Cerium	100
Zn	Zinc	5,000
Zr	Zirconium	30
Cl	Chlorine	0.05
Ca	Calcium	2
Ni	Nickel	1,000
Eu	Europium	300
Se	Selenium	6,000
Np	Neptunium	10
Y	Yttrium	20
Nb	Niobium	30
Pa	Palladium	50
Cd	Cadmium	1,000
Sn	Tin	50,000
Te	Tellurium	1,000
Pm	Promethium	500
U	Uranium	1
Be	Beryllium	
Rb	Rubidium	
Sa	Samarium	500
Pr	Praseodymium	

	Crustaceans	FC (l.kg^{-1} fresh)
H	Tritium	1
C	Carbon	5,000
I	Iodine	100
Ru	Ruthenium	300
Sb	Antimony	10
Sr	Strontium	5
Cs	Caesium	100
Co	Cobalt	5,000
Tc	Technetium	1,300
Pu	Plutonium	500
Am	Americium	1,000
Cm	Curium	1,000
Mn	Manganese	5,000
Ag	Silver	3,000
Fe	Iron	5,000
Mo	Molybdenum	100
Ce	Cerium	1,500
Zn	Zinc	4,000
Zr	Zirconium	500
Cl	Chlorine	0.05
Ca	Calcium	5
Ni	Nickel	1,000
Eu	Europium	1,000
Se	Selenium	5,000
Np	Neptunium	100
Y	Yttrium	1,000
Nb	Niobium	200
Pd	Palladium	10
Cd	Cadmium	10,000
Sn	Tin	50,000
Te	Tellurium	1,000
Pm	Promethium	1,000
U	Uranium	10
Be	Beryllium	
Rb	Rubidium	
Sm	Samarium	1,000
Pr	Praseodymium	

	Molluscs	FC ($l.kg^{-1}$ fresh)
H	Tritium	1
C	Carbon	5,000
I	Iodine	100
Ru	Ruthenium	600
Sb	Antimony	20
Sr	Strontium	10
Cs	Caesium	50
Co	Cobalt	2,000
Tc	Technetium	400
Pu	Plutonium	3,000
Am	Americium	1,000
Cm	Curium	1,000
Mn	Manganese	10,000
Ag	Silver	40,000
Fe	Iron	20,000
Mo	Molybdenum	100
Ce	Cerium	1,500
Zn	Zinc	80,000
Zr	Zirconium	1,000
Cl	Chlorine	0,05
Ca	Calcium	1
Ni	Nickel	2,000
Eu	Europium	7,000
Se	Selenium	6,000
Np	Neptunium	400
Y	Yttrium	1,000
Nb	Niobium	1,000
Pa	Palladium	500
Cd	Cadmium	20,000
Sn	Tin	50,000
Te	Tellurium	1,000
Pm	Promethium	5,000
U	Uranium	30
Be	Beryllium	
Rb	Rubidium	
Sa	Samarium	5,000
Pr	Praseodymium	

APPENDIX III.-. DISTRIBUTION COEFFICIENTS

	Sediments	Kd ($l.kg^{-1}$ dry)
H	Tritium	1
C	Carbon	2,000
I	Iodine	500
Ru	Ruthenium	5,000
Sb	Antimony	400
Sr	Strontium	30
Cs	Caesium	1,000
Co	Cobalt	40,000
Tc	Technetium	100
Pu	Plutonium	10,000
Am	Americium	30,000
Cm	Curium	20,000
Mn	Manganese	1,000
Ag	Silver	1,000
Fe	Iron	50,000
Mo	Molybdenum	
Ce	Cerium	20,000
Zn	Zinc	2,000
Zr	Zirconium	3,000
Cl	Chlorine	0.03
Ca	Calcium	500
Ni	Nickel	100,000
Eu	Europium	500,000
Se	Selenium	100,000
Np	Neptunium	1,000
Y	Yttrium	10,000,000
Nb	Niobium	500,000
Pa	Palladium	5,000,000
Cd	Cadmium	2,000
Sn	Tin	1,000
Te	Tellurium	1,000
Pm	Promethium	2,000,000
U	Uranium	1,000
Be	Beryllium	
Rb	Rubidium	
Sa	Samarium	2,000,000
Pr	Praseodymium	

PART III - APPLICATION OF THE B.A.T. TO THE RADIOACTIVE DISCHARGES OF THE EDF NUCLEAR POWER PLANTS

Photo Marc Didier

The Paluel NPP

1. CHARACTERISTICS OF FRENCH NUCLEAR PRODUCTION SITES IN THE OSPAR AREA

1.1. Nuclear Power Plants in the OSPAR area

Map reference	Name of Nuclear Power Plant	Destination of discharges	Number and type of units	Installed capacity (MWe)	Date of first divergence
F1	Belleville-sur-Loire	Loire	2 PWR	2,600	1987
F2	Le Blayais	Gironde Estuary	4 PWR	3,600	1981
F3	Cattenom	Moselle	4 PWR	5,200	1986
F4	Chinon	Loire	4 PWR	3,600	1982
F5	Chooz	Meuse	2 PWR	2,900	1996
F15	Civaux	Vienne	2 PWR	2,900	1997

Map reference	Name of Nuclear Power Plant	Destination of discharges	Number and type of units	Installed capacity (MWe)	Date of first divergence
F6	Dampierre-en-Burly	Loire	4 PWR	3,600	1980
F7	Fessenheim	Rhin	2 PWR	1,800	1977
F8	Flamanville	North Sea (Channel)	2 PWR	2,600	1985
F9	Golfech	Garonne	2 PWR	2,600	1990
F10	Gravelines	North Sea	6 PWR	5,400	1980
F11	Nogent-sur-Seine	Seine	2 PWR	2,600	1987
F12	Paluel	North Sea (Channel)	4 PWR	5,200	1984
F13	Penly	North Sea (Channel)	2 PWR	2,600	1990
F14	Saint Laurent des Eaux	Loire	2 PWR	1,800	1981

Photo Pierre MERAT

The Belleville NPP

1.2. French regulatory structure

French regulations concerning water withdrawals and discharges at Basic Nuclear Installations (INBs) comprise an assemblage of texts developed both on the international level (agreements, protocols, etc.), and within the Community (directives, regulations, etc.). They comprise general texts (laws, decrees, orders, circulars, etc.) as well as texts covering each individual nuclear installation.

During the period 2010-2014, two new and important laws have impacted the field of NPPs' discharges:

- The February 7th 2012 arrêté, modified on the June 26th 2013.
- The August 9th 2013 arrêté.

These two texts come from the continuation of the implementation of the law issued on the 6th of June 2006 on transparency and safety in nuclear activities (codified in Title IX of Book V of the French Environmental Code). These texts have enhanced the coherence between the different regulations regarding environmental protection for the French facilities.

The administration (ASN) has for instance taken advantage of these changes to set some expectancies/requirements on the discharges monitoring equipments (such as backup electrical supply for example), set some expectancies/requirements on the quality of the discharges samplings and measurements (based on the ISO/IEC 17025 standard or equivalent), set discharges regulatory accounting rules, set some minimum decision thresholds concerning radioactive environmental monitoring measurements, set some expectancies on the content of public reports...

1.3. Schedule of renewals of release permits for EDF Nuclear Power Plants (NPPs)

Administrative status	Site	Date of renewal of release permit
Renewed	SAINT LAURENT	June 2010
Renewed	FLAMANVILLE with EPR	September 2010
Renewed	DAMPIERRE	May 2011
In progress	BELLEVILLE	2014 (projected)
In progress	CATTENOM	2014 (projected)
In progress	CHINON	2015 (projected)
In progress	FESSENHEIM	2015 (projected)
In progress	SAINT LAURENT	2015 (projected)
In progress	PALUEL	2015 (projected)

Photo Marc DIDIER

The Chooz NPP

1.4. Old and new limits for radioactive liquid discharges

Category of radionuclides	Former annual limits[10] (GBq)	New annual limits (GBq)
Tritium	55,000	from 40,000 to 80,000 (High Burn-up Fraction fuel)
Iodines		0.3
Other radionuclides (excluding ^{3}H, ^{40}K, and Ra)	750	30
^{14}C	Unregulated	130

Annual limits on liquid radioactive discharges for two 900 MWe units

Category of radionuclides	Former annual limits[2] (GBq)	New annual limits(GBq)
Tritium	80,000	from 80,000 to 110,000 (High Burn-up Fraction fuel)
Iodines		0.1
Other radionuclides (excluding ^{3}H, ^{40}K, and Ra)	1,100	25
^{14}C	Unregulated	190

Annual limits on liquid radioactive discharges for two 1300 MWe units

[10] At sites where permits have not yet been renewed.

Category of radionuclides	Former annual limits[2] (GBq)	New annual limits (GBq)
Tritium	80,000	from 80,000 to 90,000 (High Burn-up Fraction fuel)
Iodines		0.1
Other radionuclides (excluding ^{3}H, ^{40}K, and Ra)	222	5
^{14}C	Unregulated	190

Annual limits on liquid radioactive discharges for two 1450 MWe units

2. OPTIMIZATION OF LIQUID RADIOACTIVE DISCHARGES FROM NUCLEAR POWER PLANTS

2.1. Description and performances of systems

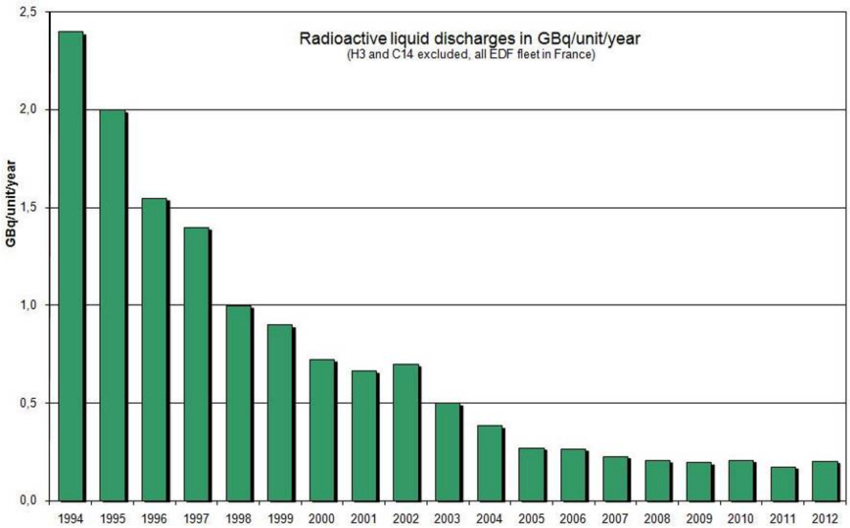
The overall regulation of Basic Nuclear Installations (INBs) is based among other things on the so-called optimization principle.

This principle has been incorporated into the design of the structures (possibility of recycling or processing the effluents) throughout the nuclear production fleet, so as to *"reduce as far as reasonably possible and at an acceptable cost"* the discharges of effluents.

With this goal in mind, since the first commissioning of the nuclear fleet the operators have endeavoured to keep discharges of effluents to a minimum. Their efforts have mainly been directed towards two kinds of action:

- Establishing a rigorous management of effluents, aimed in particular at reducing the production of effluents at the source and at recycling spent effluents (creation of a guide for research into the production of effluents, adoption of an effluent-recycling policy, etc.),
- Improvement of the systems for collecting and processing effluents.

These actions have resulted in a significant reduction in the discharges of activity by liquid effluents for all categories of radionuclides (excepted tritium and carbon 14).



Thanks to these actions, the activities discharged by EDF's nuclear power plants have now reached a very low level. The controls carried out under the environmental-monitoring program show that the terrestrial ecosystem has not been influenced by the radioactive discharges. Only the area close to the point where liquid discharges are made is slightly influenced by the discharges at trace levels.

The terrestrial ecosystem is currently characterized by the presence of traces of radionuclides produced during atmospheric testing of nuclear weapons (137Cs, 90Sr, transuranic elements) and at the time of the Chernobyl accident (137Cs). The activity is constantly reducing.

The statistical analysis of 14C measurements on environmental matrices shows a slight increase of about 1% (2 to 3 Bq/kg of carbon) in activity levels, in other words in the order of the uncertainty associated with the measurement technique, and under prevailing winds. The influence of gaseous 3H (in HTO form) discharges is not detectable.

Occasional deposits of 60Co and 54Mn, on the littoral fringe of the Manche (English Channel) and Atlantic seaboard are potentially attributable to liquid discharges from NPPs (sea sprays).

The aquatic ecosystem currently characterized by the presence of traces of radionuclides produced and attributable to old fallout (nuclear tests and Chernobyl accident) sometimes including γ emitting radionuclides (54Mn, 58Co, 60Co, 110mAg, 108mAg, 137Cs, 134Cs) from NPP operation.

In aquatic and terrestrial matrices, fallouts from the Fukushima accident in 2011 are quite undetectable.

A regular contribution of liquid radioactive discharges to the supply of 3H and 14C immediately downstream of the NPPs can also be observed as well as the presence of 131I with no direct link to NPP operation, the source of which is attributable to medical diagnostic and therapeutic applications.

It will be noted that the dosimetric impact attributable to these radionuclides is in the order of magnitude of 1 µSv/year.

However, this has not led to a slackening of the efforts being made; they are in fact being actively pursued, in order to:

- Maintain the good results obtained in the fields of discharges,
- Apply an even stricter management of effluents, so as to avoid failures and deviations (preparation of a guide to good practice),
- Take actions to improve the discharges from under-performing plants (inter-comparison of results).

Photo Philippe ERANIAN

2.2. Characterization of liquid radioactive discharges

Liquid radioactive effluents are grouped into two families, according to their origin:

- Effluents from the reactor coolant system, which may contain dissolved fission products as noble gases, iodine, caesium, etc., and activation products (cobalt, manganese, tritium, carbon 14, etc.), and also chemical substances such as boric acid and lithium. These effluents can be recycled.
- Effluents from the auxiliary circuits, which constitute the rest of the effluents.

These include:

- Effluents that are radioactively and chemically clean,
- Effluents that are radioactively and chemically loaded,
- Weakly radioactive effluents comprising drain waters from floors and "wastewaters" (showers, laundries, and washbasins).

After systematic collection, these effluents are processed to hold back most of their radioactivity. They are then sent to storage tanks, where they are subjected to radioactive or chemical analysis before being discharged.

Before any discharge, the properties of the effluent to be discharged are examined, particularly on the basis of activity checks based on a specific analysis of the radionuclides rather than on total alpha, beta or gamma measurements, and if necessary they may be sent back for additional processing. The discharge may be postponed if the possibilities of the environmental dilution capability are unfavourable, e.g., for radionuclides in rivers during low water flow periods. During discharge the radioactivity is also checked in the discharge pipe and in the environment at mid-outlet taking of surface water samples using an hydrocollector situated downstream of the NPPs within the mixing zone to ensure compliance with the specified limits for ^{3}H and gross beta activity.

If the alarm threshold fixed in the license order is exceeded, the discharge is automatically halted.

Annually, several tens of thousands of samples are taken and analysis performed both in the storage tanks, the discharge outlets and within the environment (by the operator, by the French nuclear safety authority (ASN) (scheduled on a weekly, monthly, quarterly and annual basis, as well as spot checks + cross-checking) and by NGOs).

The analysis performed by the operator under the regulations relate to:

- The discharges of liquid/gaseous radioactive and/or chemical effluents,
- The terrestrial (ambient gamma dose rate, atmospheric dust, rainwater, grass, milk, etc.) and aquatic ecosystems (plants, surface and ground water, sea, fish, etc.).

The results of the analysis are recorded in regulatory registers sent each month to the French nuclear safety authority (ASN). They are also included in the "Annual environmental monitoring report" accessible to the public. The results of the environmental radioactive monitoring are also accessible to the public on a website (www.mesure-radioactivite.fr).

2.3. Operational effectiveness

The performance of NPPs depends not only on the effectiveness of their effluent-processing systems but also on their operating practices.

The management of effluents/discharges at nuclear sites is the subject of operating instructions based on principles designed to:

- Check the quality and quantity of radioactive effluents produced/discharged,

- Control the activity discharged in compliance with environmental parameters.

In this regard, actions are implemented to reduce the production of effluents at the source and to optimize the collection and processing of effluents. This also requires the establishment of an organization dedicated to effluent management, and lastly a results-based management.

2.3.1. Reduction at the source

The following arrangements assist in reducing the production of effluents at the source.

- Plexiglas covers were installed on the inlet manifolds of some of the sumps in order to see the origin of the effluents.
- Procedures for tracking leaks were implemented.

2.3.2. Collection and processing

Spent liquid effluents are selectively collected under four categories (drain waters from floors, service-drain effluents, chemical effluents, and residual drain waters) in order to send them for the treatment that best suits their characteristics (filtration, evaporation, or demineralization).

2.3.3. Organization

The organization set up to manage effluents is designed to:

- Prevent radioactive discharges from an inappropriate manner,
- Provide for full control of effluent discharges.

This organization demands the active involvement of all the personnel concerned (awareness-raising and training). It relies in particular on making use of the experience acquired on the site and in the entire production fleet, and encourages the implementation of the best practices identified by this experience feedback.

This organization is strengthened during periods when the unit is on outage, when more effluents are produced because of the numerous maintenance activities requiring circuits to be drained.

Daily monitoring of effluent production enables discharges to be efficiently reduced during this special phase of NPPs operation.

2.4. Implementation of best available techniques and best environmental practices

As mentioned earlier, the activity discharged by nuclear power plants has greatly diminished over the last 20 years. This reduction in the activity discharged by CNPEs is due in particular:

- To a better identification of effluents at the source, so that they can be sent for appropriate treatment,
- To an increase in the treatment of effluents by evaporation,
- To improvements in the treatment processes at certain sites, in particular the flocculation of aluminium sulfate to improve the efficiency of the demineralizer processing of ^{110m}Ag,
- To optimized recycling of the effluents.

This involves all the radionuclides except tritium and carbon 14, for which the activity discharged is directly linked to the power produced. Indeed, the production of tritium is related to:

- • The amount of energy produced,
- • Design parameters,
- • The fuel enrichment rate used,

- • The duration of operating cycles between two stops for refuelling.

As regards tritium, no industrial method for trapping it exists, given the large volumes of water to be processed and the correspondingly low volume activity of this radionuclide. We should also note that tritium is one of the least toxic radionuclides. Nevertheless, EDF is currently working, through R&D programs, on tritium speciation in liquid discharges, and is involved in standardisation of tritium (and C14) measurement techniques in liquid (and also gaseous) discharges.

EDF still carries out a number of actions to optimize its discharges of tritium, as described hereafter.

2.5. Implementation by EDF of a tritium-management policy

With the aim of optimizing tritium discharges EDF set off a policy for the management of tritium (July 2007). Given that tritium cannot be trapped and that its dosimetric impact is greater for gaseous discharges rather than in liquid form, this policy sets out the following main recommendations:

- Reduce atmospheric discharges of tritium to a minimum and discharge tritium preferentially in a liquid form (mainly HTO in the case of PWR).
- Reduce the concentration of tritium in the reactor coolant system in the event of primary/secondary leaks, to limit the transfer of tritium to the secondary cooling system.
- Avoid disseminating tritium into the tanks or pools during the shutdown of a unit, by diluting the reactor coolant system before shutdowns for refuelling.

2.6. Projected operation start of the future Flamanville 3, French first EPR reactor

As regards the future EPR reactor now under construction at Flamanville, its design and operation are intended to further improve the best environmental performances obtained at current nuclear power plants. This reactor includes in its design the recycling and advanced selective sorting of liquid effluents, allowing optimization of their processing. These design arrangements make it possible to achieve release levels lower than those at other units of the fleet, in comparison with the power produced, except for tritium and carbon 14 discharges (because of the greater power of this reactor). The regulatory limits for discharges from the EPR, which cover its normal operation and routine operational uncertainties, were established by the Administration according to current regulations, and were set conservatively in order to meet environmental and health concerns. They incorporate industrial improvements from the operating nuclear fleet. They were set after an examination of the environmental impact study submitted to the public inquiry. The starting of operation is planned for 2016.

3. INVENTORY OF LIQUID RADIOACTIVE DISCHARGES

3.1. Accounting rules

By creating new categories of radionuclides, the latest discharge permits have made it necessary to alter the system of accounting for radioactive effluents. This new system was implemented on the Saint-Laurent site for the year 1999, and then on the Paluel, Flamanville, and Belleville sites according to the publication date of their discharge orders. It has been used at all of the power plants in EDF's nuclear fleet since January 2002.

The new accounting system is based on a radionuclide-by-radionuclide analysis rather than on total beta or total gamma spectrometry. In addition, liquid and gaseous discharges are increased on purpose to the uncertainty of measurement when below half of the detection limit. This accounting rule is now included in the August 9th 2013 arrêté, for all nuclear plants.

The rules thus primarily rely on the definition of a reference spectrum. For liquid discharges, this spectrum consists in a list of radionuclides that must be identified by appropriate measurement methods. The second basic rule consists in a mandatory declaration of the activity discharged by the radionuclides belonging to the reference spectrum. Radionuclides whose measured activity is less than half of the detection limit of the analytical technique are systematically recorded at a value equal to half of the detection limit (i.e.; decision threshold). The objective is to overestimate the activity of the discharge by introducing the uncertainty of measurement. Thus certain frequently-occurring radionuclides (said to belong to the reference spectrum), like iodine for example, are at a minimum recorded at a value corresponding to half of the detection limit (e.g. decision threshold).

3.2. Inventory of liquid discharges

The radioactivity discharged by the radionuclides monitored for OSPAR, beta and gamma emitters as well as tritium and C14, are given in the tables below for the years 2009 to 2012.

2009															
Site	Discharges to	Number and type of reactor	Capacity MWe	Total electrical Output MWe.h	Tritium	C 14[11]	Co 58	Co 60	Zn 65	Zr/Nb 95	Ag 110m	Sb 125	Cs 134	Cs 137	Other radio-nuclides
					GBq										
Belleville	Loire	2 PWR	2,600	3.22 E8 MWe.h	5.35E+04	29.8	1.38E-01	6.80E-02			2.30E-02	1.50E-02	1.00E-02	3.40E-02	3.60E-01
Cattenom	Mosel	4 PWR	5,200		8.25E+04	60.7	1.66E-01	2.74E-01			4.10E-02	5.50E-02	3.10E-02	9.00E-02	7.66E-01
Chinon	Loire	4 PWR	3,600		5.10E+04	34.7	5.40E-02	9.20E-02			3.40E-02	3.80E-02	1.30E-02	1.70E-02	2.94E-01
Chooz	Meuse	2 PWR	2,900		4.17E+04	29.4	4.50E-02	1.77E-01			2.50E-02	1.30E-01	1.30E-02	4.40E-02	5.21E-01
Civaux	Vienne	2 PWR	2,900		3.92E+04	35.5	1.10E-02	4.10E-02			1.14E-01	1.50E-02	5.00E-03	8.00E-03	2.00E-01
Dampierre	Loire	4 PWR	3,600		4.22E+04	42.1	1.42E-01	7.70E-02		1.98E-04	2.50E-01	5.10E-02	2.00E-02	2.50E-02	6.95E-01
Fessenheim	Rhine	2 PWR	1,800		2.43E+04	15.6	8.30E-02	3.70E-02			1.49E-01	1.50E-02	5.00E-03	1.00E-02	3.47E-01
Flamanville	North Sea	2 PWR	2,600		5.70E+04	29.4	7.20E-02	9.00E-02			1.20E-02	3.20E-02	1.10E-02	1.30E-02	2.30E-01
Golfech	Garonne	2 PWR	2,600		5.73E+04	35	5.70E-02	4.70E-02			8.00E-03	1.80E-02	6.00E-03	1.00E-02	1.82E-01
Gravelines	North Sea	6 PWR	5,400		7.07E+04	66.8	7.20E-02	3.02E-01			1.84E-01	7.00E-02	2.70E-02	1.07E-01	8.52E-01
Le Blayais	Gironde	4 PWR	3,600		3.61E+04	38.5	1.60E-01	2.40E-01			1.71E-01	4.00E-02	1.60E-02	2.30E-02	7.26E-01
Nogent-	Seine	2 PWR	2,600		4.53E+04	25.9	8.30E-02	3.50E-02			1.30E-02	3.00E-02	1.30E-02	1.70E-02	2.30E-01
Paluel	North Sea	4 PWR	5,200		8.62E+04	52.7	3.91E-01	2.80E-01			4.60E-02	1.07E-01	3.90E-02	5.10E-02	1.06
Penly	North Sea	2 PWR	2,600		5.66E+04	31.8	8.40E-02	1.43E-01			3.70E-02	3.10E-02	9.00E-03	1.30E-02	4.02E-01
Saint Laurent	Loire	2 PWR	1,800		2.20E+04	22.4	8.10E-02	5.50E-02	7.36E-04	2.90E-03	1.90E-02	1.80E-02	7.00E-03	9.00E-03	2.94E-01

[11] Carbone 14 liquid discharges data have been added to OSPAR standard discharges chart. These data are calculated values. The calculated values use conservative assumptions as hypothesis (UNSCEAR (2000) Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation, Report to the General Assembly, with scientific annex. Part 1, annex C United Nations, New York. EPRI TR-105715, project 2724-04, final report, November 1995: « Characterization of carbon-14 generated by the nuclear power industry »)). Actions are implemented with the French organization for normalisation of C14 measurements in liquid and gaseous discharges.

2010														
Site	Discharges to	Number and type of reactor	Capacity MWe	Total electrical Output MWe.h	Tritium	C 14[2]	Co 58	Co 60	Zr/Nb 95	Ag 110m	Sb 125	Cs 134	Cs 137	Other radio-nuclides
					GBq									
Belleville	Loire	2 PWR	2,600	4.09 E8 MWe.h	5.91E+04	25.9	8.80E-02	7.0E-02		1.50E-02	4.50E-02	1.40E-02	2.20E-02	3.10E-01
Cattenom	Mosel	4 PWR	5,200		1.18E+05	62.9	2.36E-01	2.8E-01	7.98E-04	5.80E-02	7.60E-02	3.20E-02	7.60E-02	8.90E-01
Chinon	Loire	4 PWR	3,600		4.52E+04	37.4	5.90E-02	7.3E-02		2.01E-01	5.20E-02	1.50E-02	2.00E-02	4.80E-01
Chooz	Meuse	2 PWR	2,900		6.36E+04	34.5	6.70E-02	2.6E-01	4.99E-04	3.20E-02	6.50E-02	1.30E-02	3.60E-02	5.40E-01
Civaux	Vienne	2 PWR	2,900		6.23E+04	38.7	6.00E-03	2.2E-02		3.10E-02	1.50E-02	8.00E-03	1.00E-02	1.30E-01
Dampierre	Loire	4 PWR	3,600		5.01E+04	44.8	1.75E-01	9.4E-02	3.77E-04	7.60E-02	7.90E-02	1.60E-02	2.30E-02	6.10E-01
Fessenheim	Rhine	2 PWR	1,800		3.09E+04	20.9	1.28E-01	6.7E-02	7.27E-04	1.91E-01	2.90E-02	5.00E-03	1.00E-02	4.70E-01
Flamanville	North Sea	2 PWR	2,600		4.93E+04	28.7	1.14E-01	1.2E-01		1.80E-02	4.90E-02	1.30E-02	1.50E-02	3.70E-01
Golfech	Garonne	2 PWR	2,600		6.01E+04	32	3.80E-02	5.6E-02		7.00E-03	2.10E-02	7.00E-03	9.00E-03	1.70E-01
Gravelines	North Sea	6 PWR	5,400		7.40E+04	65.5	1.91E-01	9.9E-01	6.60E-04	3.50E-01	6.60E-02	4.50E-02	1.03E-01	1.98
Le Blayais	Gironde	4 PWR	3,600		4.61E+04	47.3	8.30E-02	1.9E-01		1.22E-01	3.30E-02	1.40E-02	2.20E-02	5.40E-01
Nogent	Seine	2 PWR	2,600		7.15E+04	32.9	1.02E-01	4.9E-02		1.80E-02	5.10E-02	2.00E-02	2.70E-02	3.30E-01
Paluel	North Sea	4 PWR	5,200		8.86E+04	58.9	2.63E-01	2.5E-01		4.60E-02	1.06E-01	4.10E-02	5.20E-02	9.60E-01
Penly	North Sea	2 PWR	2,600		6.48E+04	29.6	1.40E-02	6.2E-02		7.00E-03	1.60E-02	6.00E-03	1.70E-02	1.60E-01
Saint Laurent	Loire	2 PWR	1,800		2.03E+04	24.3	5.40E-02	8.5E-02		3.50E-02	1.70E-02	7.00E-03	1.00E-02	2.60E-01

2011														
Site	Discharges to	Number and type of reactor	Capacity MWe	Total electrical Output MWe.h	Tritium	C 14[2]	Co 58	Co 60	Zr/Nb 95	Ag 110m	Sb 125	Cs 134	Cs 137	Other radio-nuclides
					GBq									
Belleville	Loire	2 PWR	2,600	4.42 E+08 MWe.h	5.87E+04	32.6	3.80E-02	4.90E-02	-	1.10E-02	2.90E-02	1.00E-02	1.30E-02	2.06E-01
Cattenom	Mosel	4 PWR	5,200		8.82E+04	62.2	2.65E-01	4.61E-01	-	4.50E-02	9.30E-02	4.00E-02	9.30E-02	1.17
Chinon	Loire	4 PWR	3,600		5.42E+04	46	5.70E-02	7.20E-02	-	1.58E-01	2.80E-02	1.00E-02	1.20E-02	3.81E-01
Chooz	Meuse	2 PWR	2,900		5.23E+04	38.7	5.10E-02	1.89E-01	-	2.10E-02	2.40E-02	1.10E-02	3.20E-02	3.75E-01
Civaux	Vienne	2 PWR	2,900		2.98E+04	34.5	6.00E-03	3.00E-02	-	5.30E-02	1.00E-02	4.00E-03	7.00E-03	1.69E-01
Dampierre	Loire	4 PWR	3,600		4.49E+04	44.3	7.10E-02	6.90E-02	-	3.80E-02	4.90E-02	1.60E-02	2.40E-02	3.62E-01
Fessenheim	Rhine	2 PWR	1,800		1.22E+04	12.7	9.20E-02	3.10E-02	-	1.29E-01	2.30E-02	4.00E-03	5.00E-03	3.30E-01
Flamanville	North Sea	2 PWR	2,600		6.35E+04	33.7	1.09E-01	6.40E-02	-	1.50E-02	4.30E-02	1.40E-02	1.80E-02	3.32E-01
Golfech	Garonne	2 PWR	2,600		6.49E+04	33.3	1.90E-02	2.70E-02	-	8.00E-03	2.20E-02	7.00E-03	8.00E-03	1.30E-01
Gravelines	North Sea	6 PWR	5,400		7.54E+04	67.3	1.20E-01	8.12E-01	-	2.73E-01	9.20E-02	5.00E-02	8.50E-02	1.64
Le Blayais	Gironde	4 PWR	3,600		4.88E+04	46.7	1.02E-01	8.20E-02	-	5.00E-02	2.90E-02	9.00E-03	1.20E-02	3.50E-01
Nogent	Seine	2 PWR	2,600		5.84E+04	32.9	2.10E-01	3.80E-02	-	3.90E-02	4.50E-02	1.60E-02	1.90E-02	4.29E-01
Paluel	North Sea	4 PWR	5,200		1.10E+05	67.9	2.95E-01	1.89E-01	-	3.30E-02	7.50E-02	2.90E-02	3.50E-02	8.38E-01
Penly	North Sea	2 PWR	2,600		5.84E+04	31.8	4.90E-02	5.80E-02	-	3.30E-02	1.40E-02	6.00E-03	1.10E-02	1.97E-01
Saint Laurent	Loire	2 PWR	1,800		2.15E+04	20.2	2.30E-02	6.10E-02	-	4.00E-02	1.70E-02	7.00E-03	9.00E-3	1.90E-01

2012														
Site	Discharges to	Number and type of reactor	Capacity MWe	Total electrical Output MWe.h	Tritium	C 14[2]	Co 58	Co 60	Zr/Nb 95	Ag 110m	Sb 125	Cs 134	Cs 137	Other radio-nuclides
					GBq									
Belleville	Loire	2 PWR	2,600	3.15 E+08 MWe.h	5.98E+04	34.7	1.10E-01	2.20E-02	-	1.00E-02	3.10E-02	2.80E-02	3.20E-02	2.70E-01
Cattenom	Mosel	4 PWR	5,200		1.23E+05	54.6	2.07E-01	5.18E-01	-	7.80E-02	7.00E-02	2.60E-02	4.70E-02	1.10
Chinon	Loire	4 PWR	3,600		5.70E+04	48.1	6.30E-02	1.14E-01	-	1.14E-01	5.50E-02	1.10E-02	1.30E-02	4.18E-01
Chooz	Meuse	2 PWR	2,900		5.55E+04	32.5	1.20E-01	1.23E-01	-	2.20E-02	2.20E-02	9.00E-03	1.60E-02	5.60E-01
Civaux	Vienne	2 PWR	2,900		6.73E+04	28.9	1.70E-02	1.00E-01	-	6.00E-02	1.40E-02	5.00E-03	6.00E-03	3.10E-01
Dampierre	Loire	4 PWR	3,600		4.27E+04	41.6	2.87E-01	2.32E-01	-	6.70E-02	4.10E-02	1.60E-02	2.40E-02	7.44E-01
Fessenheim	Rhine	2 PWR	1,800		3.13E+04	22.1	3.20E-02	3.80E-02	-	9.30E-02	2.50E-02	4.00E-03	5.00E-03	2.37E-01
Flamanville	North Sea	2 PWR	2,600		5.87E+04	30.6	1.11E-01	9.30E-02	-	1.80E-02	7.30E-02	1.80E-02	2.10E-02	4.10E-01
Golfech	Garonne	2 PWR	2,600		4.88E+04	28.2	1.02E-01	4.50E-02	-	8.00E-03	2.40E-02	7.00E-03	1.00E-02	2.40E-01
Gravelines	North Sea	6 PWR	5,400		5.74E+04	57.2	3.06E-01	1.09	-	6.07E-01	8.70E-02	3.70E-02	6.50E-02	2.39
Le Blayais	Gironde	4 PWR	3,600		3.95E+04	43.1	2.62E-01	2.19E-01	-	2.22E-01	6.80E-02	1.60E-02	3.90E-02	9.12E-01
Nogent	Seine	2 PWR	2,600		3.79E+04	29.1	1.78E-01	1.50E-01	-	4.30E-02	4.40E-02	1.50E-02	1.90E-02	5.80E-01
Paluel	North Sea	4 PWR	5,200		9.56E+04	60.7	2.34E-01	2.46E-01	-	4.30E-02	4.20E-02	1.70E-02	3.10E-02	7.30E-01
Penly	North Sea	2 PWR	2,600		6.97E+04	31.4	1.85E-01	2.20E-01	-	1.10E-02	1.90E-02	7.00E-03	8.00E-03	5.20E-01
Saint Laurent	Loire	2 PWR	1,800		2.28E+04	23.5	1.10E-02	3.70E-02	-	3.00E-02	1.70E-02	6.00E-03	8.00E-03	1.34E-01

3.3. Quality Assurance/Deviation Management (significant events)

The monitoring of environment-related events within the EDF is ensured by a two-level process: local (by the CNPEs) and national (by a special network). This network investigates events that are deemed to be major issues, occurring at French and foreign nuclear power plants.

Depending on their level of importance, these events are the subject of appropriate handling either at the national (generic aspect) or local level.

Each event is immediately declared to the Administration. If the event is considered to be significant, a report is prepared and sent to the Administration.

The French nuclear safety authority requires to be immediately informed when a regulatory provision is not met by the declaration of an Environmental Significant Event or ESE or when a minor equipment malfunction occurs by the declaration of an Environmental Interesting Event or EIE.

Since 2000, no event taking place at a French power station has led to a significant increase in dosimetric impact attributable to liquid discharges.

Photo Bruno CONTY

4. CONTROL OF DISCHARGES AND ENVIRONMENTAL MONITORING

The operator is required to establish a program for controlling discharges and monitoring the environment. This program, defined in the discharge permit, is designed to ensure a proper management of discharges and control of their impact on the environment and on population.

Controls on discharges are in particular designed to check on the figures stipulated in the authorizing order both for withdrawals of water and for radioactive discharges. These controls are defined for each parameter (activity, volume activity, and emission rate) covered by a license application.

In addition to these controls, the operator performs environmental-monitoring measurements whose goal is to assess the impact of its installation's operations. This monitoring comprises:

- Periodic measurements of certain radiochemical parameters, in terms of masse or volume activity or specific activities,
- Continuous monitoring of the parameters,
- Radioecologic surveys.

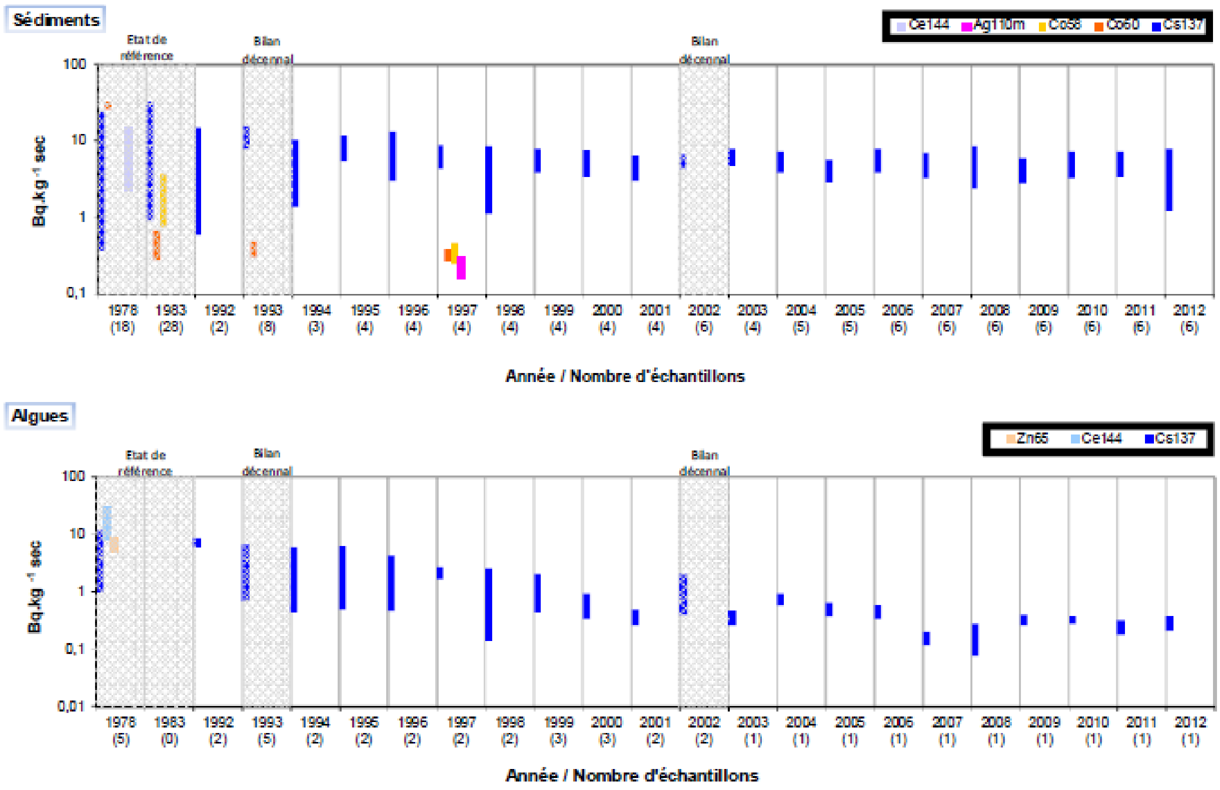
Photo Philippe ERANIAN

The radioecologic measurements carried out around nuclear sites allow estimates of the impact of the chronic discharges from a NPP under normal operating condition. These measurements, which cover both land-based and aquatic ecosystems, are performed every year (annual monitoring) and particularly address tritium and the gamma-emitting radionuclides that are present in the discharges. They are supplemented by studies carried out every ten years over the lifetime of nuclear installations (ten-year inventory), which cover a greater variety of matrices and radionuclides. These results are compared with radioecologic data collected before the start up of the facility (radioecological zero point).

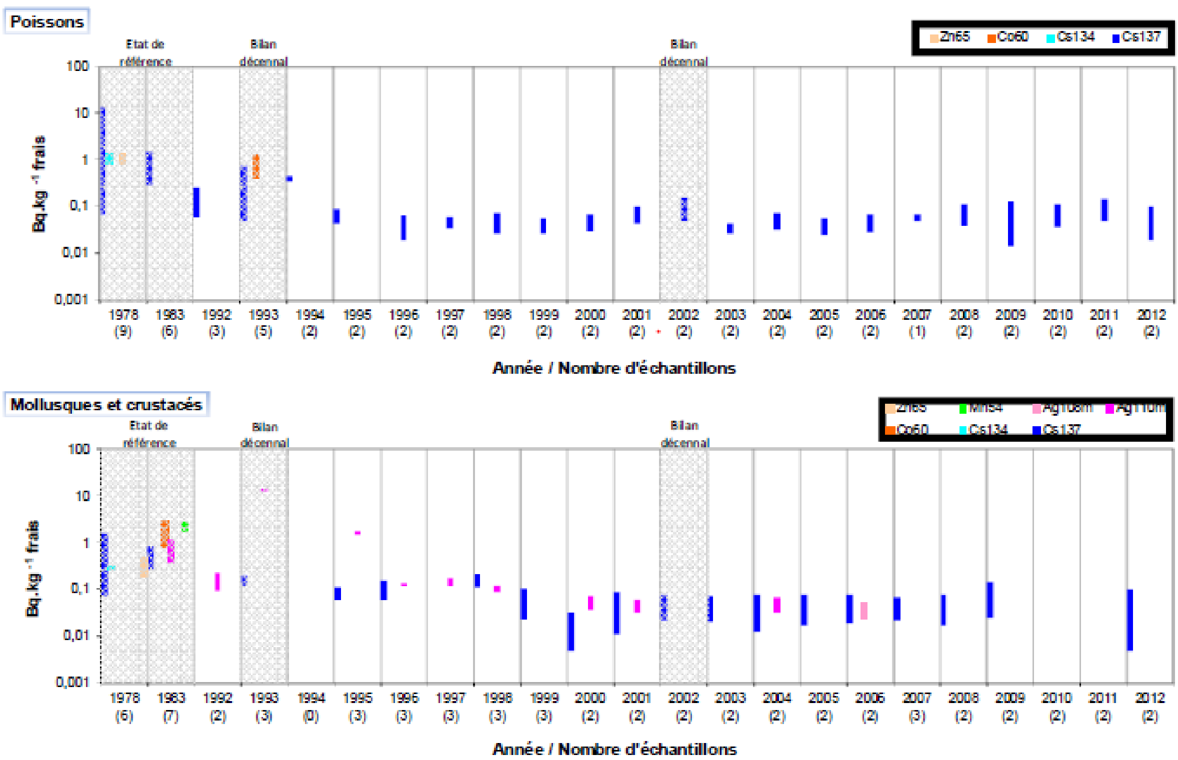
The control and monitoring procedures take into account the experience acquired since work began in this field. They represent an optimized system of control and monitoring, based on the most pertinent data and practices. A summary of the results for the marine sites is presented in the tables hereafter[12].

[12] NB: These data are in addition to the data that France regularly sends directly to OSPAR.

Blayais NPP

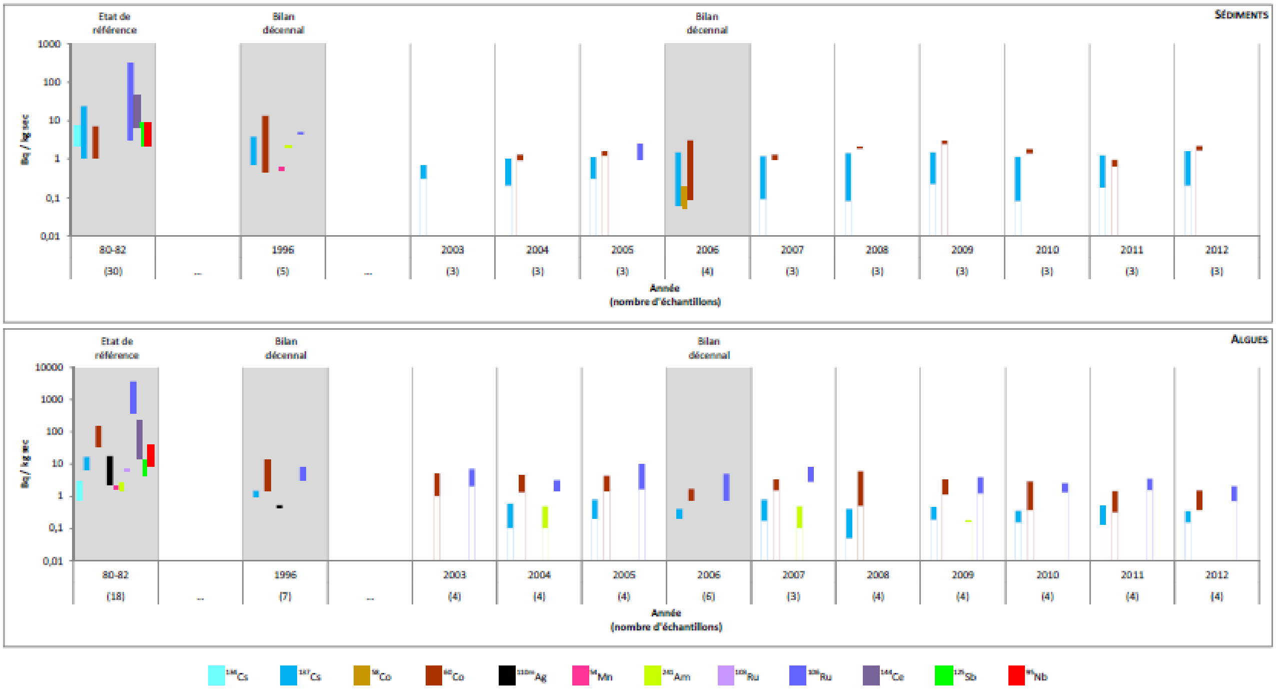


Temporal variation of activity (min and max values) for artificial radionuclides measured by gamma spectrometry in sediments and algae in the marine environment of Blayais NPP.

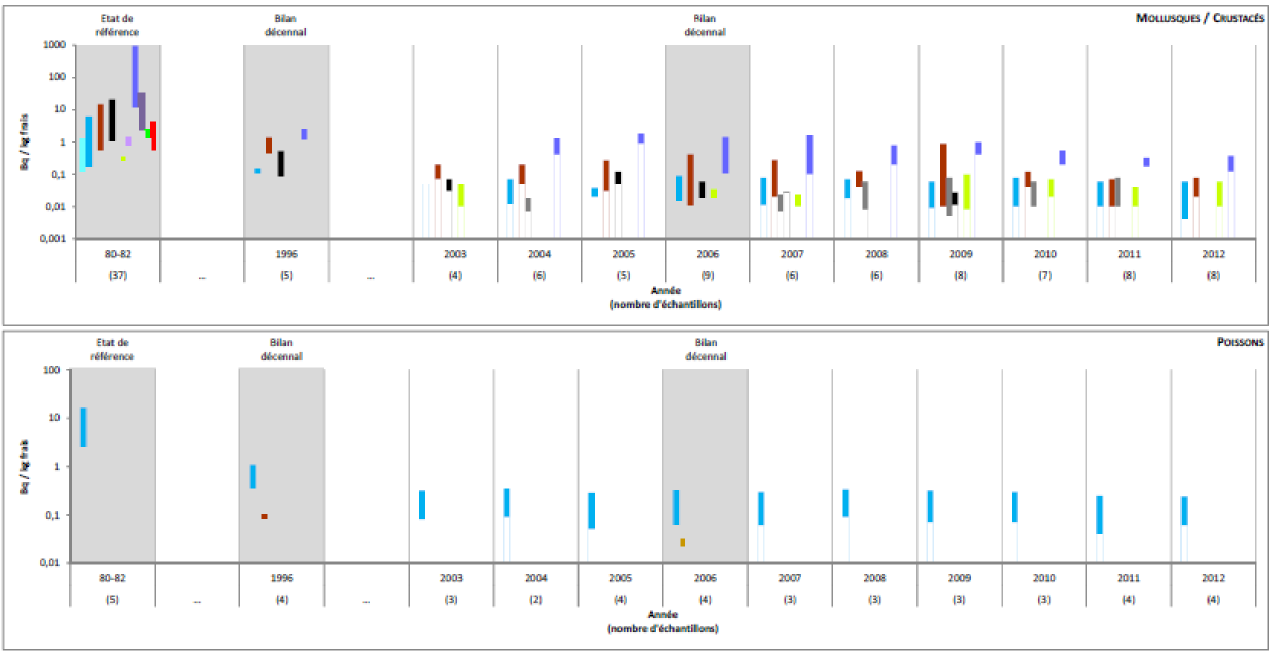


Temporal variation of activity (min. and max. values) for artificial radionuclides measured by gamma spectrometry in molluscs, crustaceans and fishes in the marine environment of Blayais NPP.

Flamanville NPP

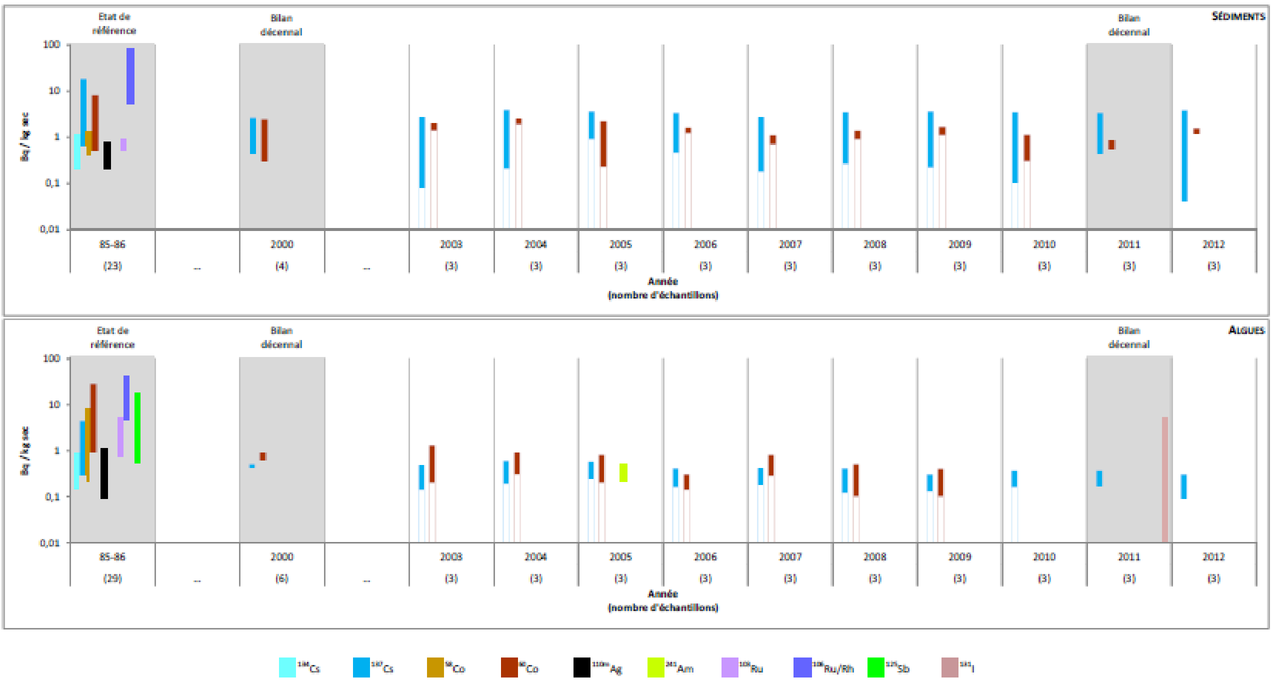


Temporal variation of activity (min and max values) for artificial radionuclides measured by gamma spectrometry in sediments and algae in the marine environment of Flamanville NPP.

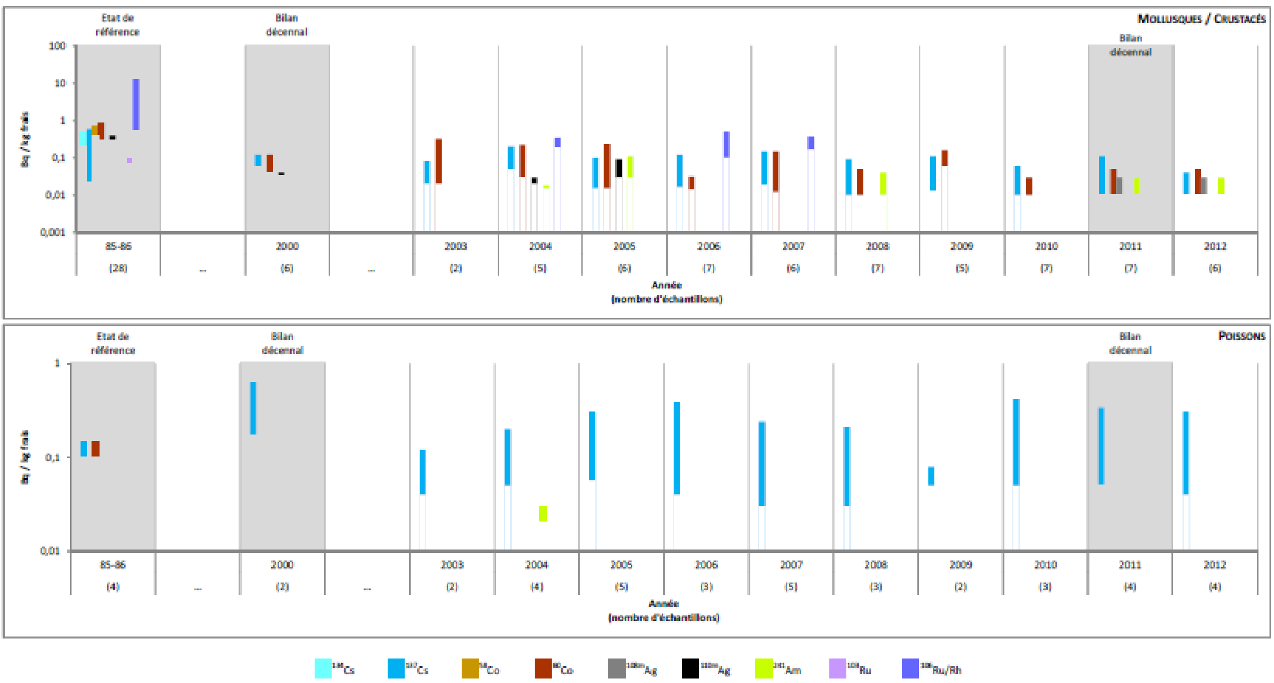


Temporal variation of activity (min. and max. values) for artificial radionuclides measured by gamma spectrometry in molluscs, crustaceans and fishes in the marine environment of Flamanville NPP.

PENLY NPP

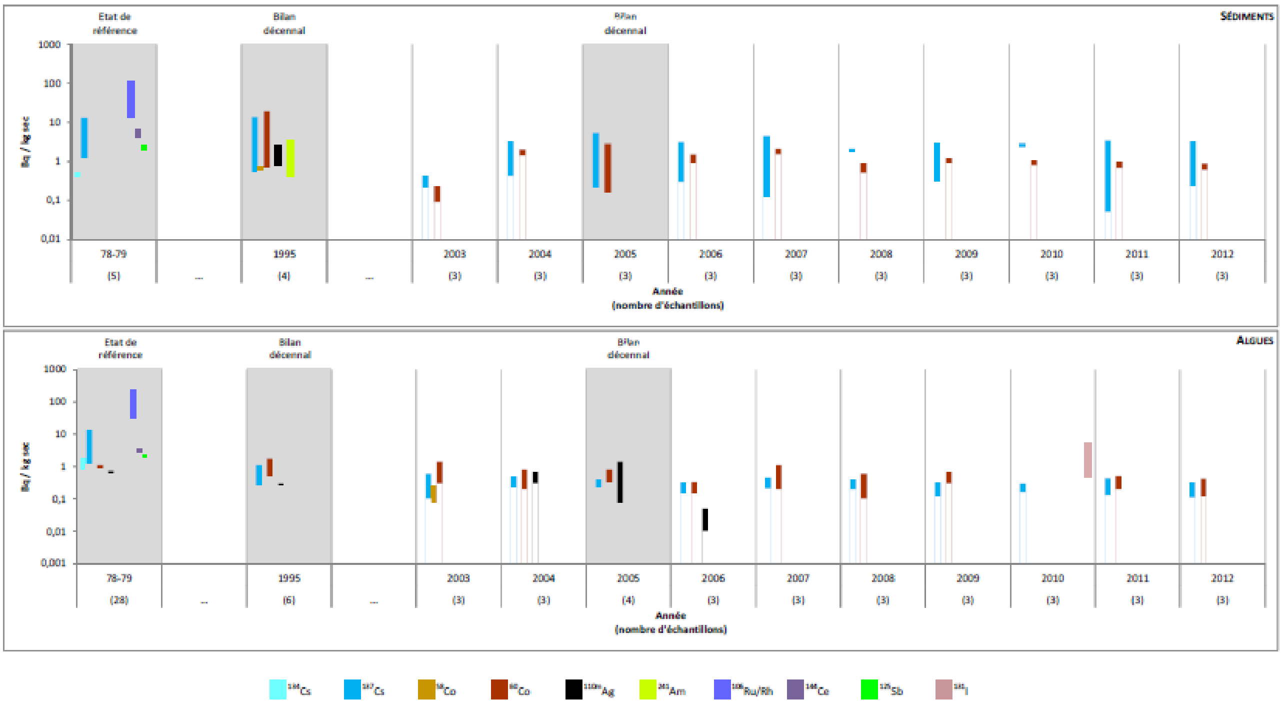


Temporal variation of activity (min and max values) for artificial radionuclides measured by gamma spectrometry in sediments and algae in the marine environment of Penly NPP.

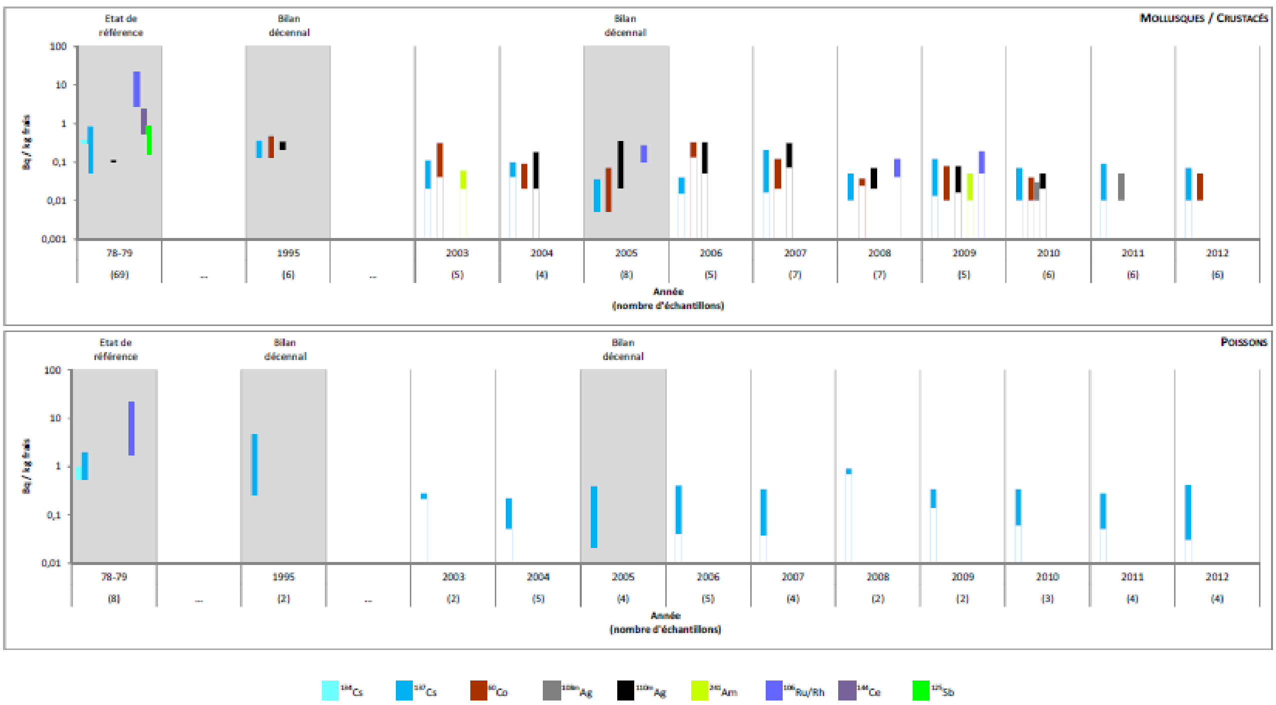


Temporal variation of activity (min. and max. values) for artificial radionuclides measured by gamma spectrometry in molluscs, crustaceans and fishes in the marine environment of Penly NPP.

Paluel NPP

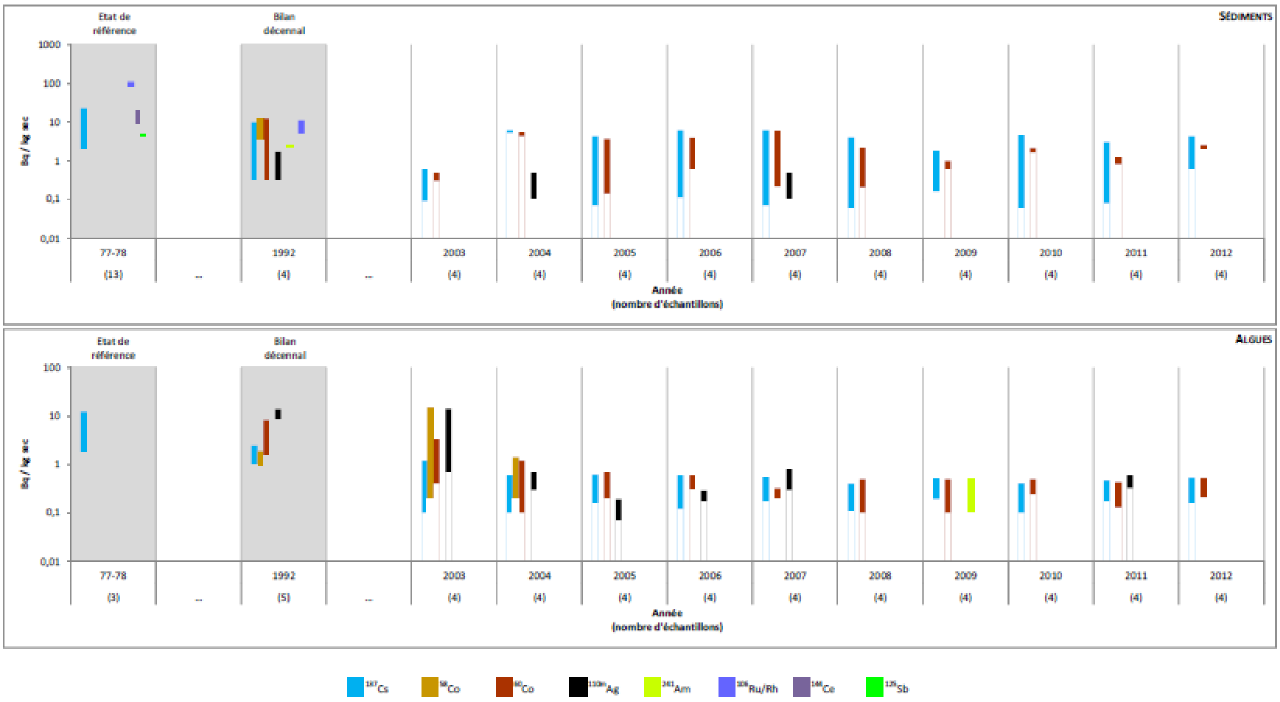


Temporal variation of activity (min and max values) for artificial radionuclides measured by gamma spectrometry in sediments and algae in the marine environment of Paluel NPP.

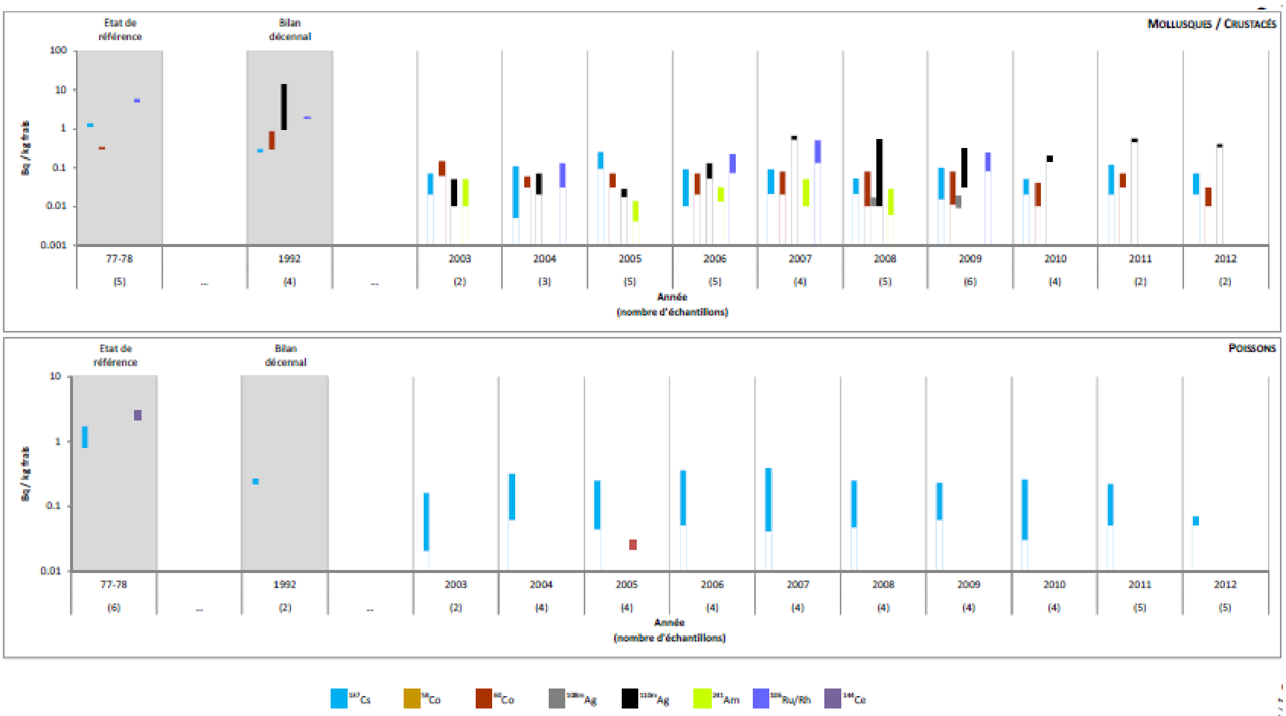


Temporal variation of activity (min. and max. values) for artificial radionuclides measured by gamma spectrometry in molluscs, crustaceans and fishes in the marine environment of Paluel NPP.

Gravelines NPP



Temporal variation of activity (min and max values) for artificial radionuclides measured by gamma spectrometry in sediments and algae in the marine environment of Gravelines NPP.



Temporal variation of activity (min. and max. values) for artificial radionuclides measured by gamma spectrometry in molluscs, crustaceans and fishes in the marine environment of Gravelines NPP.

5. RADIOLOGICAL IMPACT OF MARINE SITES

Studies of the radiological impact of NPPs rely heavily on a methods manual prepared at the request of the Directorate-General for Health, and approved by France's Senior Council for Public Health. The computer tools used by EDF to calculate doses were the subject of a comparative analysis as part of the Nord-Cotentin study in 1999. The results obtained are similar to those obtained using other calculation codes. In addition to the food intake specific to each NPP, the model for calculating the dose also includes, for marine sites, external exposures due to 100 hours of exposure on the beach and 20 hours/year of swimming with ingestion of seawater (1 L/year). Calculations of the annual dose are a recent requirement of the regulations. In accordance with the regulations they are performed annually for the adults in the reference group's population for all sites, and broken down radionuclide by radionuclide since 2009.

The transfer functions between activity and dose were updated in 2010 using the properties shown in the tables below, also taking into account meteorological actualization, new constructions, some changes in food habits. These tables also show the total effective dose attributable to discharges of liquid radioactive effluents (including tritium and calculated carbon 14) for the years 2009 to 2012 and for the present exercise for marine OSPAR sites.

	Years	Annual total dose due to liquid discharges, in microSv
Le Blayais	2009	0.16
	2010	0.18
	2011	0.19
	2012	0.18

Characteristics of the "Le Bastion" Reference Group		
Food intake (kg/year):		
	Root vegetables	52.5
	Leafy vegetables	14.4
	Fruiting vegetables and fruits	62.1
	Milk	84.4
	Meat	47.5
	Fish	18.3
	Molluscs	2.3
	Crustaceans	2.3

	Years	Annual total dose due to liquid discharges, in microSv
Flamanville	2009	0.24
	2010	0.23
	2011	0.27
	2012	0.24

Characteristics of the "Hameau es Louis" Reference Group		
Food intake (kg/year):		
	Root vegetables	31.4
	Leafy vegetables	4.6
	Fruiting vegetables and fruits	59.6
	Milk	97.8
	Meat	47.8
	Fish	13
	Molluscs	6.7
	Crustaceans	7.1

	Years	Annual total dose due to liquid discharges, in microSv
Paluel	2009	0.20
	2010	0.22
	2011	0.25
	2012	0.22

Characteristics of the "Le Tot" Reference Group		
Food intake (kg/year):		
	Root vegetables	57
	Leafy vegetables	13
	Fruiting vegetables and fruits	52.5
	Milk	93.9
	Meat	43.6
	Fish	18.3
	Molluscs	8.4
	Crustaceans	8.4

	Years	Annual total dose due to liquid discharges, in microSv
Penly	2009	0.35
	2010	0.35
	2011	0.34
	2012	0.37

Characteristics of the "Vassonville" Reference Group		
Food intake (kg/year):		
	Root vegetables	57
	Leafy vegetables	13
	Fruiting vegetables and fruits	52.5
	Milk	93.9
	Meat	43.6
	Fish	18.3
	Molluscs	8.4
	Crustaceans	8.4

	Years	Annual total dose due to liquid discharges, in microSv
Gravelines	2009	0.34
	2010	0.36
	2011	0.36
	2012	0.35

Characteristics of the "Espace culturel Decaestecker" Reference Group		
Food intake (kg/year):		
	Root vegetables	93
	Leafy vegetables	11.8
	Fruiting vegetables and fruits	42.3
	Milk	68.9
	Meat	44.3
	Fish	24.4
	Molluscs	6.8
	Crustaceans	6.8

PART IV: APPLICATION OF THE B.A.T. TO THE RADIOACTIVE DISCHARGES OF THE CEA RESEARCH CENTRES

CEA FONTENAY-AUX-ROSES CENTRE

1. SITE CHARACTERISTICS

The site concerned is known as "CEA de Fontenay-aux-Roses".

1.1. Type of facility

The site currently consists of research laboratories (life sciences, robotics, etc.) and two basic nuclear installations (INB) in the cleanup and dismantling phase.

1.2. Start of operations and decommissioning

The French Alternative Energies and Atomic Energy Commission (CEA) centre at Fontenay-aux-Roses, the first CEA research centre, was created in March 1946. Several generations of nuclear facility have been constructed there. They were in operation until their gradual decommissioning occurred between 1982 and 1995. Up until 2006, there were 4 INB on the site. Since then, only 2 INB remain: INB165 known as "INB procédé" (Process-INB) and INB166 known as "INB support" (Support-INB).

1.3. Location

The site is located in the district of Fontenay-aux-Roses (Department 92), several kilometres from Paris.

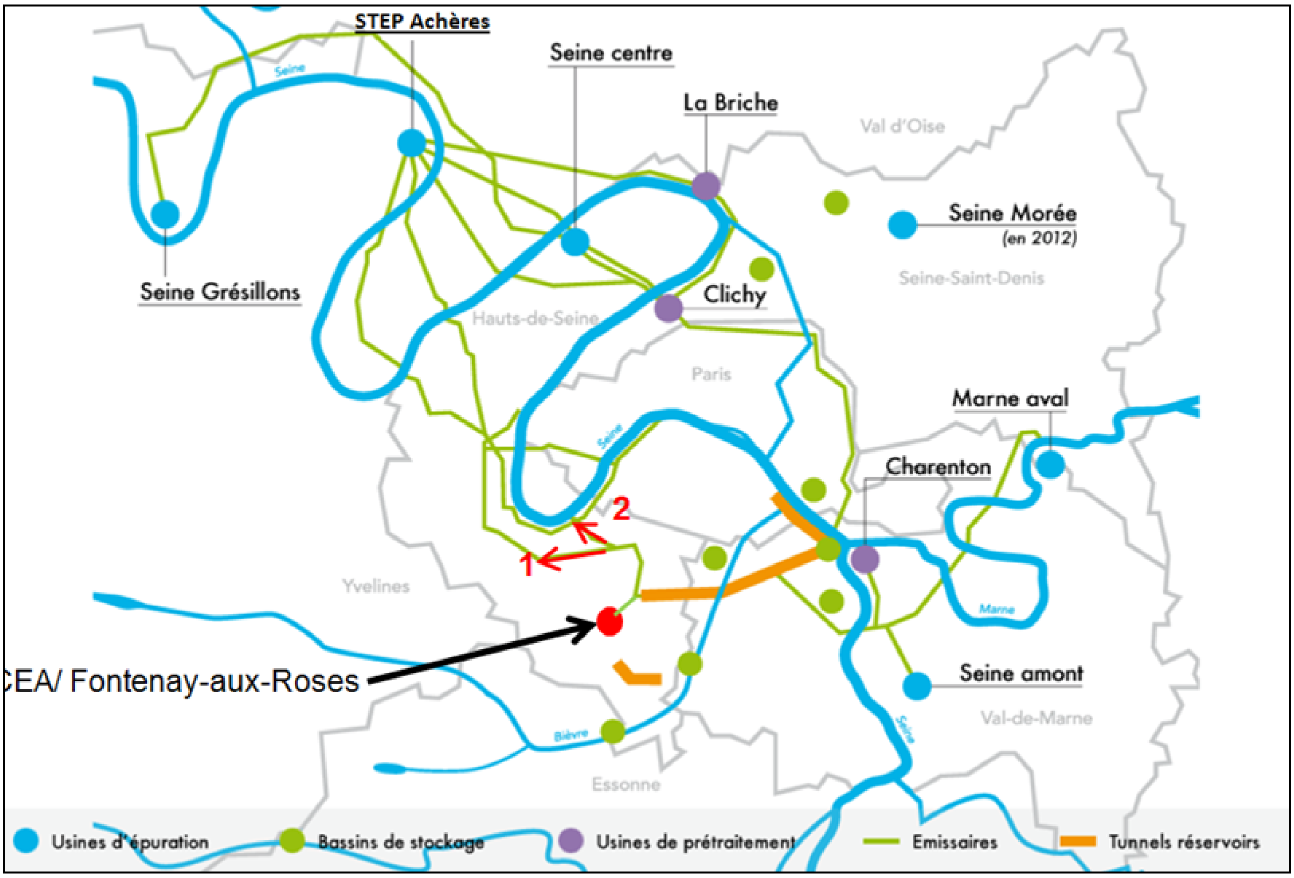
1.4. Receiving waters and catchment area

All of the radioactive effluents are stored and then evacuated following processes which depend on the specific nuclear sector concerned.

Liquid effluents which are likely to contain traces of radioactivity are stored in the laboratory's tanks. These effluents are inspected before authorisation for discharge is granted, in accordance with the decree of March 30,1988 relating to discharges from the centre and to the authorisation of liquid and gaseous effluent discharges by the nuclear industry research centre at Fontenay-aux-Roses.

Monitoring programs for liquid effluent discharges, put in place at CEA Fontenay-aux-Roses, also comply with the regulation on authorisation of discharges of non-domestic wastewater from this establishment into the public sewage network of the Department of Hauts-de-Seine. This decree, dated March 1st, 2011, was established by the Hauts-de-Seine General Council.

The characteristics of the effluents conform to the regulations in these decrees. The discharge is made directly into the communal and departmental sewerage systems, following the methods defined in the waste directives of the centre; these internal specifications define the procedures that must be followed in order that the regulations are adhered to. The waters are then transported to the purification plant at Achères (30 km from the site), which then discharges the treated effluent into the Seine.



Network of receiving waters

Setting-up of the points of takings of sewage

1.5. Production

The centre is dedicated to research. There are no research reactors active on the site.

2. DISCHARGES

2.1. Systems in place to reduce, prevent or eliminate discharges and emissions

In general, the methodology applied for cleanup, waste management procedures as specified in waste studies and the waste directives of the centre, all contribute to the overall reduction of discharges and emissions.

With regard to liquid discharges:

- The SABINE facility (Station d'Assainissement des Boues Issues du Nettoyage des Égouts – Sewage plant for the cleansing of slurry resulting from the cleaning of sewers), created in 1993, is used to treat slurry resulting from cleaning of the sewer network at the centre, from the bottom of the tanks and the underground technical galleries. The slurry effluents are collected by hydro-cleaning and then treated by settling filtration. The dehydrated slurries and clarified effluents are then directed towards the appropriate waste management processes.
- The retention tanks were created in 2003 and 2004 in order to recover any water used for extinguishing a fire in one of the INB (the retention tanks are sized to be able to recover water used in the most serious extinguishing scenario conceivable).

The programme of denuclearisation of the centre, which is currently in progress, will include the cleanup and complete dismantling of the INB. This process will be accompanied by ever smaller gaseous effluent and liquid discharges which will remain at the current level during the cleanup phase in-order that they are subsequently abated.

2.2. Efficiency of the abatement systems

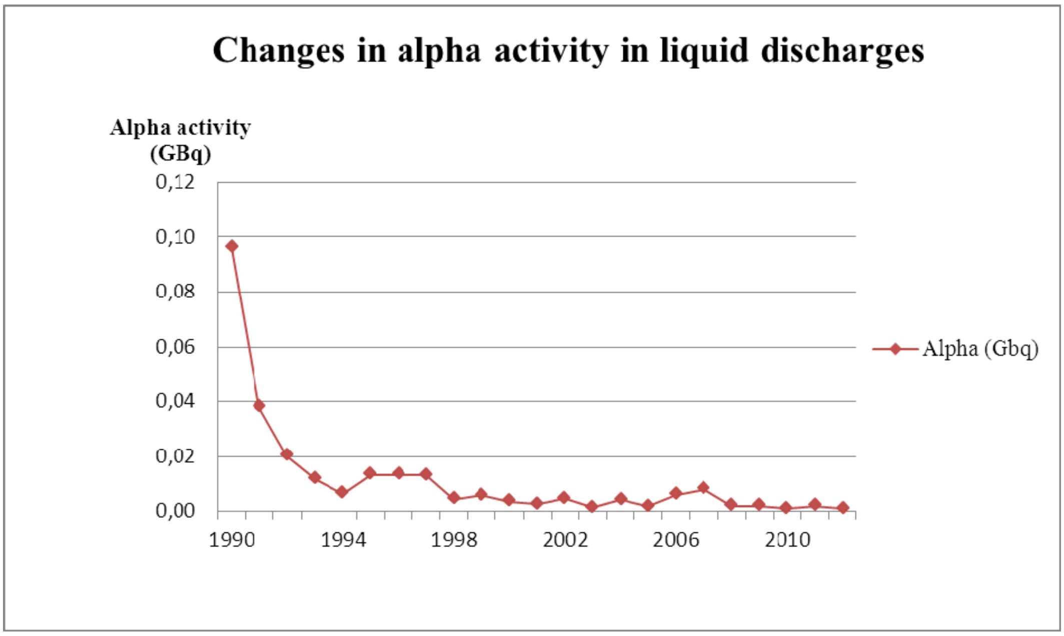
Annually, the SABINE facility produces on average around 5 m^3 of very low level activity waste (dehydrated slurries) and 100 m^3 of liquid effluents which are discharged into the urban server (after inspections according to the waste directives of the centre).

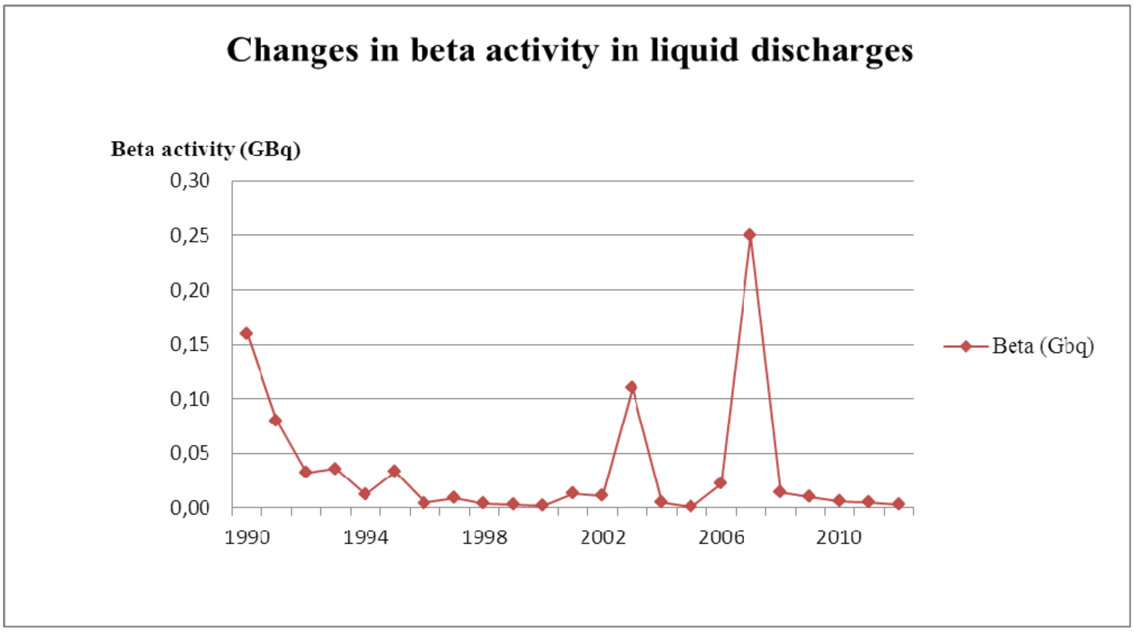
2.3. *Annual liquid discharges*

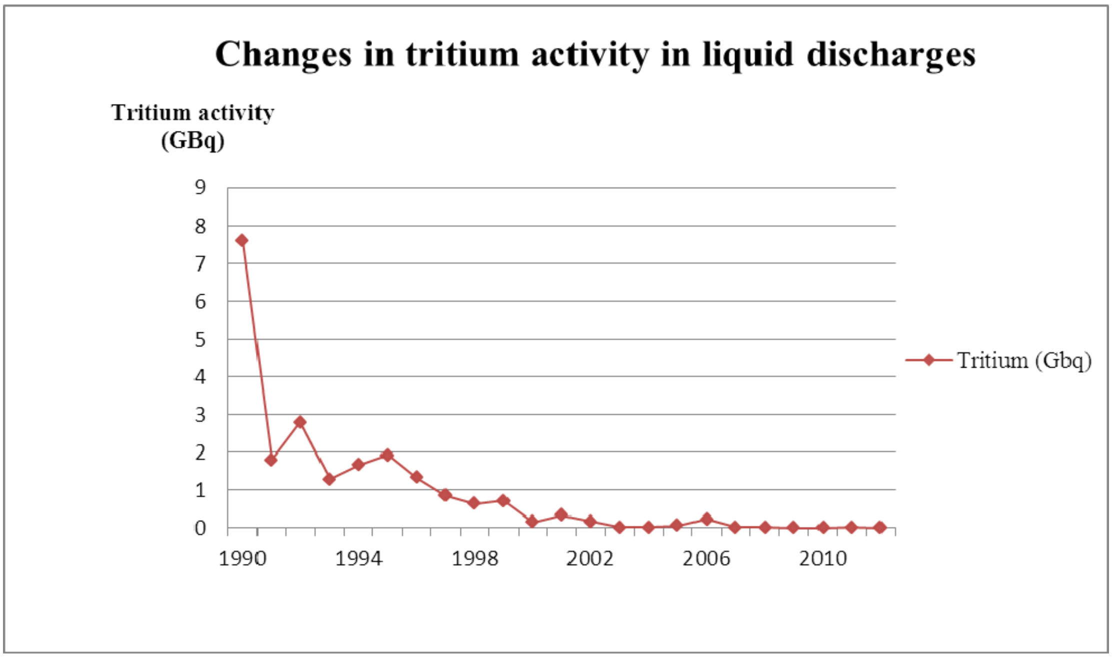
The annual liquid discharge activities are summarized in the table below:

Discharges in GBq	Alpha emitters	Beta emitters *	Tritium
1990	9.60E-02	1.60E-01	7.60E+00
1991	3.80E-02	8.00E-02	1.80E+00
1992	2.02E-02	3.20E-02	2.80E+00
1993	1.16E-02	3.60E-02	1.28E+00
1994	6.50E-03	1.20E-02	1.66E+00
1995	1.32E-02	3.30E-02	1.92E+00
1996	1.32E-02	4.65E-03	1.33E+00
1997	1.30E-02	8.80E-03	8.50E-01
1998	4.50E-03	4.20E-03	6.40E-01
1999	5.90E-03	3.00E-03	7.10E-01
2000	3.60E-03	2.20E-03	1.50E-01
2001	2.70E-03	1.30E-02	3.30E-01
2002	4.60E-03	1.10E-02	1.70E-01
2003	1.30E-03	1.10E-01	9.00E-03
2004	4.30E-03	5.00E-03	6.30E-03
2005	1.70E-03	1.00E-03	6.30E-02
2006	6.00E-03	2.20E-02	2.20E-01
2007	8.00E-03	2.50E-01	1.60E-02
2008	2.00E-03	1.40E-02	1.10E-02
2009	2.00E-03	1.00E-02	5.00E-03
2010	1.00E-03	6.00E-03	5.00E-03
2011	2.00E-03	5.00E-03	1.40E-02
2012	1.00E-03	3.00E-03	6.00E-03

*The wide variations observed result from the diversity of cleanup and dismantling works for the facilities.




Changes in beta activity in liquid discharges
Beta activity (GBq)
0,30
0,25
0,20
0,15
0,10
0,05
0,00
1990
1994
1998
2002
2006
2010
Beta (Gbq)


Changes in tritium activity in liquid discharges
Tritium activity (GBq)
9
8
7
6
5
4
3
2
1
0
1990
1994
1998
2002
2006
2010
Tritium (Gbq)

2.4. Quality systems for data retention and management

The support units at the centre as well as the INB are ISO 9001 certified.

2.5. Summary evaluation

Criterion	Evaluation
MTD/MPE indicators:	
Relevant systems put in place	Relevant systems
Decontamination or abatement factor	Effective systems
Downward trend in discharges	The downward trend has been significant for more than 10 years. There are no more INB in operation.
Comparison with values recorded by similar facilities	*Not applicable*
Relevance and reliability of the quality assurance systems	Relevant quality assurance systems
Relevance of the target	yes
Comprehensive nature of the data communicated	yes
Reasons for variation compared to the indicators	*Not applicable*
Uncertainties	Determined
Other information	*Not applicable*

3. ENVIRONMENTAL IMPACT

3.1. Concentration of radionuclides in environmental samples

The CEA centre at Fontenay-aux-Roses does not discharge directly into the marine environment, but rather into the Seine after passing through the purification station at Achères, via the water sewerage network.

The large dilution which occurs, by a factor of order 50,000 between the discharge into the urban sewage water network (20 m^3/h or $5.5.10^{-03}$ $m^3.s^{-1}$ on average) and discharge into the Seine (mean flow of $1.0.10^6$ m^3/h or 278 $m^3.s^{-1}$) should be noted.

If the mean flow at the mouth of the Seine ($10.0.10^6$ m^3/h or 2,780 $m^3.s^{-1}$) is also considered, then the dilution factor increased to 500,000.

By considering the values measured during the last four years, from 2008 to 2012, the concentration of radionuclides added to the urban sewage water network, downstream of the centre, is seen to be on average of order 10 $Bq.m^{-3}$ for alpha emitters, 40 $Bq.m^{-3}$ for beta emitters and 50 $Bq.m^{-3}$ for tritium. At the mouth of the Seine, taking account of the dilution factor, the concentrations will have been of order $1.3.10^{-05}$ $Bq.m^{-3}$ for alpha emitters, $6.4.10^{-05}$ $Bq.m^{-3}$ for beta emitters and $6.9.10^{-05}$ $Bq.m^{-3}$ for tritium.

3.2. *Environmental monitoring program*

The environmental monitoring program is described in the monitoring plan which defined the requirements of the decree of March 30, 1988.

For liquid discharges, around the clock monitoring is performed of effluents passing into the centre’s two drainage channels and from these into the urban sewage downstream from all the outflow points at the centre. There are similar checks on the groundwater, re-emergence points and lakes.

Sampling frequencies are varied and range from daily sampling to annual sampling.

The number of annual samplings is around 1,000; these are taken from the urban sewers, water mains, drainage channels, groundwater, re-emergence points, surface water and rainwater. The measurements performed on the samples amounted to a total of around 4,100 analyses per year; these are mainly for analysis of the total alpha and beta counts as well as tritium and carbon-14 analyses.

3.3. *Quality assurance systems for the environmental monitoring*

The support units at the centre have obtained ISO 9001 certification (in particular, for the process of controlling the environmental impact of the centre's activities).

The analysis laboratories are COFRAC (French committee of accreditation) accredited according to standard NF EN ISO/CEI 17025 and the other technical standards in force. The Site and Environment Monitoring Laboratory has approvals delivered by the French Nuclear Safety Authority to provide environmental radioactivity measurements which are performed as part of the national measurement network (decree of July 8, 2008).

3.4. *Summary evaluation*

Criterion	Evaluation
MTD/MPE indicators:	
Downward trends in the concentrations	Effective downward trends since the shutdown of the INB
Relevance of the environmental monitoring programme	Relevant programme
Relevance and reliability of the quality assurance systems	Appropriate and reliable systems
Comprehensive nature of the data communicated	Yes
Reasons for variation compared to the indicators	*Not applicable*
Uncertainties	Determined
Other information	*Not applicable*

4. IONISING RADIATION DOSES RECEIVED BY THE PUBLIC

4.1. Mean annual doses for individuals from the critical group

The annual exposure of the local critical group due to liquid discharges is summarised in the table below:

Year	2008	2009	2010	2011	2012
Exposure (mSv)	1.5E-07	1.3E-07	9.6E-08	9.8E-08	3.9E-08

The mean value for the period 2008-2012 is $1.0.10^{-7}$ mSv per year. The methodology is described briefly in section 4.4.

4.2. Definition of the critical group

The critical group is made up of individuals working eight hours per day in the fields fertilized with slurries from the purification centre at Achères and irrigated with water from the Seine.

4.3. Exposure routes considered

It is assumed that all radioactivity discharged by the CEA centre at Fontenay-aux-Roses arrives at the Achères purification station. The individuals in the critical group:

- exclusively consume products cultivated in these fields;
- consume fish caught in the Seine downstream from Achères;
- drink reprocessed water from the Seine.

Note: no allowance is made for any radioactivity in the Seine due to natural radioactive elements or due to radioisotopes coming from other facilities.

4.4. Methodology for estimating doses

Doses are estimated using the "ABRICOT" code, employing a source term which corresponds to the effective discharges.

4.5. Quality assurance systems for dose estimates

The CEA belongs to a centre of expertise, developed by its Analysis, Surveillance and Environment Department (DASE), at Bruyères-le-Châtel.

4.6. Relevant information not covered by the preceding headings

In response to the law requiring transparency in nuclear safety matters (law N° 2006-686 of June 13, 2006), the CEA Fontenay-aux-Roses centre compiles an annual public report containing, in particular, the provisions for safety and radiological protection in the INB, as well as the results of measurements of discharges and their impact on the environment.

4.7. Summary evaluation

Criterion	Evaluation
MTD/MPE indicators:	
Downward trends in doses	The doses are very low since the shutdown of the INB
Lower exposure than the constraint	*Not applicable*
Relevance of the critical group	Critical group chosen in a relevant way
Realism and reliability of the dose estimates	The dose estimates are reliable and sufficiently realistic
Relevance of the targets	*Not applicable*
Relevance and reliability of the quality assurance systems	Appropriate and reliable systems are in place
Comprehensive nature of the data communicated	Yes
Reasons for variation compared to the indicators	Not applicable because of the very low doses obtained.
Uncertainties	*Not applicable*
Other information	*Not applicable*

CEA SACLAY CENTRE

5. SITE CHARACTERISTICS

5.1. Name of site

The CEA Saclay centre, with 5,000 researchers, is the largest of the CEA centres. Located on an area of around 150 hectares, it houses research and innovation of the highest quality on the national and European scales. It is characterised by a wide diversity of activities, ranging from fundamental research to applied research in very varied areas and disciplines, such as astrophysics, nuclear physics, particle physics, metallurgy, electronics, biology, nuclear medicine, pharmacology, climatology, numerical simulation, chemistry and the environment.

Five primary research directions are pursued there: research in physical sciences, nuclear applications research, health research, technological research and studies of the environment. The CEA Saclay centre also houses the National Institute for Nuclear Science and Technology (INSTN) whose mission is focused on higher education and training.

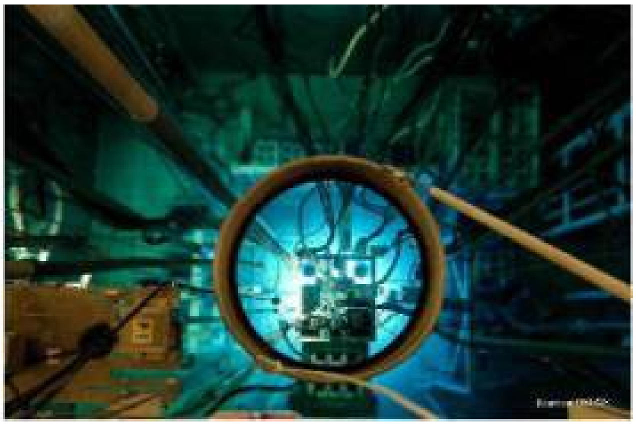
Aerial view of the centre at Saclay

5.2. Type of facility

The CEA Saclay centre has eight basic nuclear installations (INB) and around 80 facilities classified for environmental protection (ICPE); these are the research laboratories. The eight INB are the following:

- two open pool-type research reactors and one teaching reactor, the latter being permanently shut down,
- two high-level activity laboratories for the study of irradiated materials, of which one is now in the dismantling phase,
- two reprocessing facilities for radioactive liquid effluent and solid radioactive waste,
- an irradiation facility with a mission to study radiosterilisation of products intended for medical use.

The company IBA/CIS Bio International is situated on the edge of the site. It manufactures and sells radiopharmaceutical products for medical use and contains an INB.



The CEA's OSIRIS reactor

The CEA's ORPHEE reactor

5.3. Dates of commissioning/ granting of a licence/ decommissioning

Research was first performed at CEA Saclay at the start of the 1950s. The key dates for the 8 INB at the centre are the following:

- the two open pool type research reactors achieved criticality on September 8, 1966 for the OSIRIS
- reactor (INB 40) and on December 19, 1980 for the ORPHEE reactor (INB 101),
- the teaching reactor ULYSSE (INB 18), of the Argonaut type, achieved criticality on July 23, 1961 and its final shutdown was pronounced on February 9, 2007,
- the high-level activity laboratory (LHA – INB 49) gradually increased its operations from 1954 to 1960 and its final decommissioning took place on September 18, 2008,
- the irradiated fuel research laboratory (LECI – INB 50) was commissioned in November 1959; a second line of shielded cells was commissioned in 1970 and an extension with a third line of shielded cells became operational in October 2005,
- the radioactive liquid effluent reprocessing and management area (INB 35) has been in existence since 1958. Its last major overhaul consisted of constructing a new evaporator and a workshop for cementation of concentrates which operation has started in 2011,
- the solid radioactive waste management area (INB 72) was authorised in June 1971,
- and finally, the irradiation facility POSEIDON (INB 77) was authorised in August 1972.

5.4. Location

The CEA Saclay centre is located around 20 km south-west of Paris, with average coordinates of latitude 48°43’ North and longitude 2°09’ East (see map in appendix A).

5.5. Receiving waters and catchment area

The industrial waste water produced by the CEA Saclay centre is sent, after treatment, into the Saclay ponds, from where the waters flow on into the “Ru de Vauhallan” and then into the Bièvre and the Seine before finally reaching the English Channel. The dilution factor at the mouth of the Seine, when compared to the mean flow of industrial water produced, is around 50,000.

Aerial view of the Saclay centre and the ponds

5.6. Production

The OSIRIS reactor has a thermal power of 70 MW(th) and the ORPHEE reactor has a power five times less, 14 MW(th). During its operation, the teaching reactor, ULYSSE, had an almost zero power output. No energy production (heat or electricity) is coming from these reactors.

5.7. Other relevant information

Radioactive liquid effluent, produced by the various facilities at CEA's Saclay centre, is collected exclusively in dedicated tanks, or drums in the case of small producers. For this type of effluent, there is no network of channels on the site which could carry it to a direct or indirect discharge point. Rather, these effluents are transported in special road tankers to the radioactive liquid effluent treatment centre, which is part of INB 35 known as STELLA, and are treated there. After a very major renovation programme including, in particular, the commissioning of a new evaporator and a new cementation workshop, the facility has started in 2011 for radioactive effluent treatment. The volumes treated will rise gradually to between 1,000 and 1,500 m^3 per year.

View of the STELLA facility

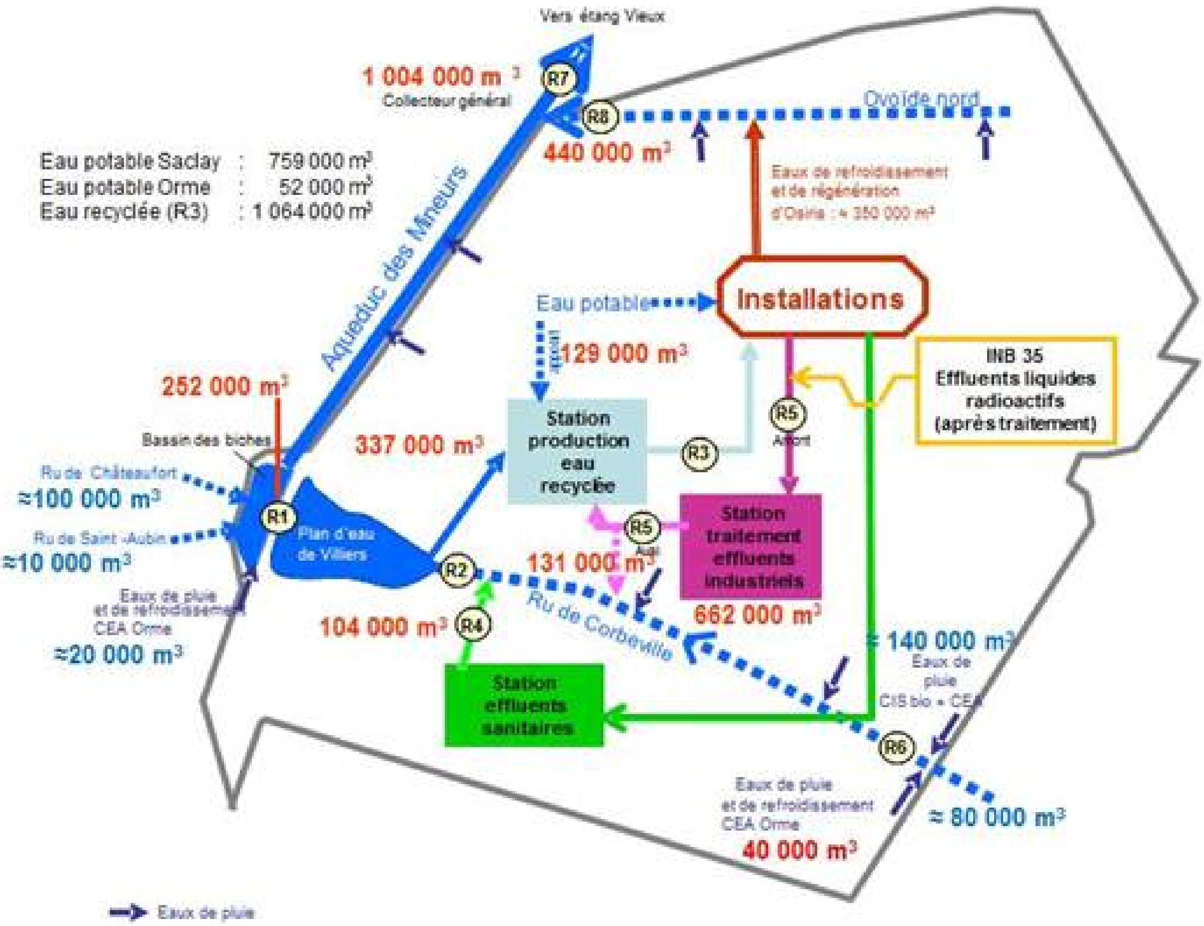
The evaporator at the STELLA facility

DISCHARGES

5.8. Systems in place to reduce, prevent or eliminate discharges and emissions

Apart from the radioactive liquid effluent treatment station referred to in 1.7 above, which has units for distillation of effluents and cementation of salts which have concentrated the radioactivity, the CEA Saclay centre also possesses:

- a facility which includes processes of neutralisation, settling, pre-chlorination, coagulation, filtration through sand, neutralisation by sodium hydroxide and post chlorination. It treats industrial effluents coming from the various laboratories and for produces recycled water starting with the majority of these processed effluents, which is intended to reduce consumption of drinking water by supplying the cooling circuits of the research reactors and the various facilities;
- a sewage plant (settlement, digestion, biological treatment, clarification) which has been replaced in 2012 by a new one (membrane filter type) in order to significantly reduce discharge of nitrate and phosphates.



Water cycle at CEA-Saclay (2012 data)

5.9. Efficiency of the abatement systems

The decontamination factor for radioactive liquid effluent is around 10^4, except for tritium and carbon-14. Tritiated and/or carbon effluents, separately collected, can be added to the cement after distillation. The cement fixes the radioactive concentrates.

Ultimately, the waste water discharged into the natural environment complies with the radioactivity limits defined by European directive 98/83 on water intended for human consumption.

5.10. *Annual liquid discharges*

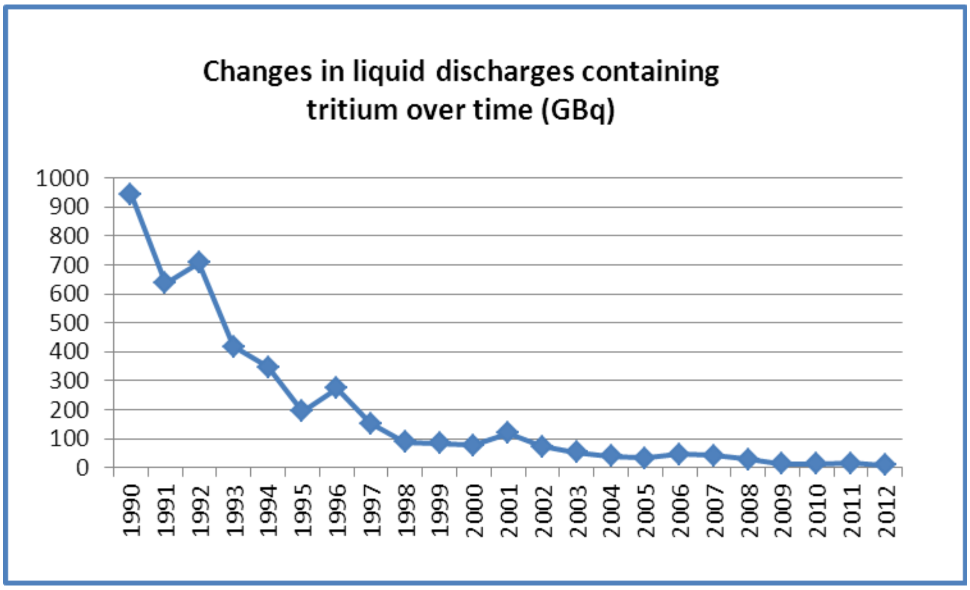
The total annual liquid discharges from the CEA Saclay centre (including those from IBA/CIS Bio International) are presented in the table below for the period 2003-2012.

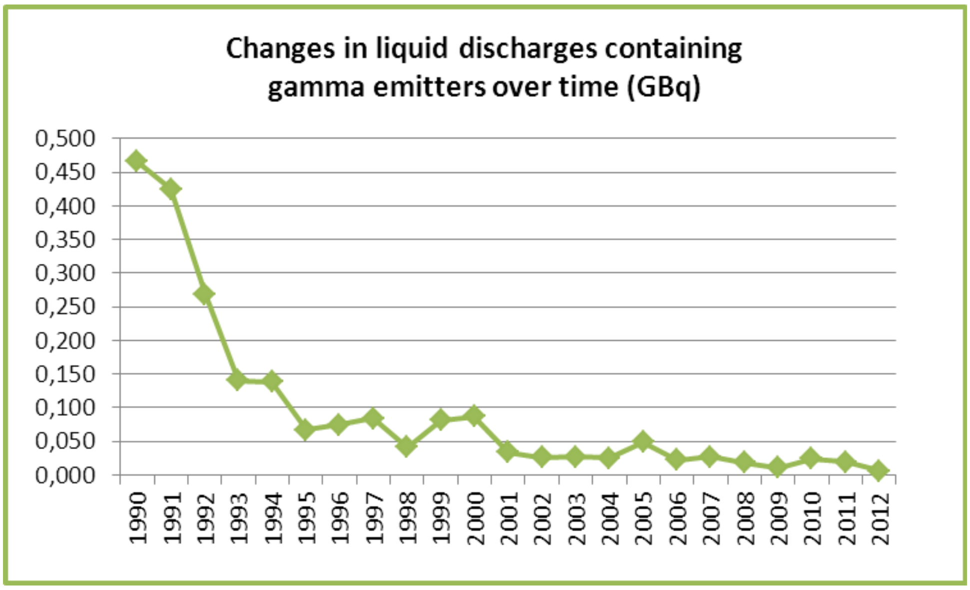
Discharges in GBq	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
H-3	53	41	33	48	43	30	13	15	17	10
Alpha-emitters*	< 0.10	< 0.10	<0.09	<0.10	<0.11	<0.06	<0.044	<0.044	<0.045	<0.040
Gamma-emitters	0. 027	0.025	0.049	0.022	0.027	0.019	0.011	0.016	0.014	0.002
Pure beta (without H-3)	0.87	0.83	0.78	1.09	1.19	0.72	0.46	0.050	0.053	0.049

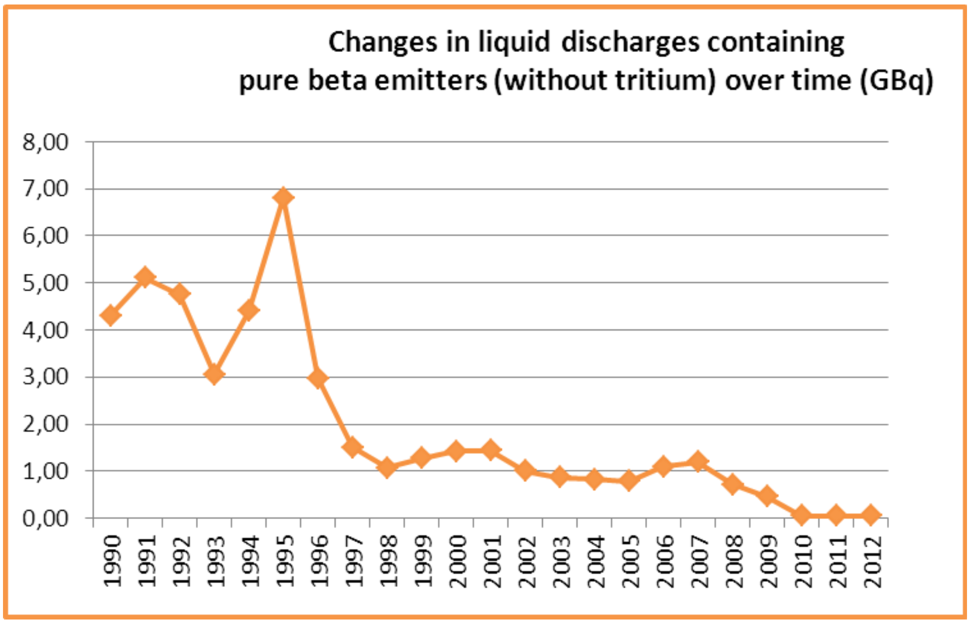
* The actual discharges of α-emitters are very low: Pu-238+239+240 + Am-241 radioactivity is less than 10^{-5} GBq in 2012.

Pure beta emitters essentially consist of carbon-14, discharges of which were responsible for 0.045 GBq in 2012. Since 2010 a new C-14 measurement method with a lower detection limit has been implemented.

As demonstrated by the plots showing the monitored changes in discharges over time of tritium, gamma emitters and pure beta emitters, it can be seen that since the start of the 1990s there has been a net reduction in liquid discharges which varies from a factor of 5 to 30 depending on the radionuclide, or groups of radionuclides, considered.







5.11. Quality systems for data retention and management

The CEA Saclay centre is

- ISO 9001-2008 certified for technical support, logistics and administrative activities, and in the areas of safety, health and the environment (AFAQ N° QUAL/2004/23042);
- and ISO 14001-2004 certified for all its facilities (AFAQ N° ENV/2004/23050).

5.12. Target values for releases from the site

The CEA Saclay centre requires authorisation for its liquid discharges, which was recently modified. The table below shows the annual authorised liquid discharges from CEA Saclay in force since 25 September 2009.

Depending on the category of radionuclides, the reduction factor of the new regulations on discharges, compared to those previously in force, lies between 4 and 30.

	Radionuclides	Annual authorisations GBq
Liquid releases	H-3	250
	Alpha emitters	0.2
	C-14	2
	Other beta-gamma emitters	0.5

Annual authorisations of liquid discharges from CEA Saclay

5.13. Summary evaluation

Criterion	Evaluation
MTD/MPE indicators	
Relevant systems put in place	Relevant systems
Decontamination or abatement factor	Effective systems
Downward trend in discharges	The downward trend is significant: depending on the radionuclide, reductions by a factor of between 10 and 100 over 30 years, and between 5 and 30 since 1990.
Comparison with values recorded by	Not applicable
Relevance and reliability of the quality assurance systems	Relevant quality assurance systems
Relevance of the target	yes
Comprehensive nature of the data communicated	yes
Reasons for variation compared to the indicators	Not applicable
Uncertainties	Determined
Other information	Not applicable

6. ENVIRONMENTAL IMPACT

6.1. *Concentration of radionuclides in environmental samples*

The water from CEA Saclay discharged into the natural environment after treatment, flows into the old and new ponds at Saclay, and then along the “Ru de Vauhallan” into the Bièvre, before flowing into the Seine. Their radionuclide concentration is very low, as shown in the following table. The levels of Sr-90, Cs-137 and Pu-239+240 are comparable, moreover, to those observed in the North Atlantic.

Concentrations in Bq/l	H-3	C-14	Cs-137	Pu-239+240
Water flowing into the ponds at Saclay (annual average 2012)	9.7	0.044	$1.7.10^{-3}$	$<2.9.10^{-6}$
Surface waters of the North Atlantic Ocean(samples 1992-1993)	-	-	Between$1.6.10^{-3}$ and $2.6.10^{-3}$	Between $10^{-6}$and 12.10^{-6}

6.2. *Environmental monitoring program*

Considering the very low environmental impact of the activities at CEA Saclay, monitoring of the physical environment and the local biotope is carried out over a radius of around 5 km.

This closer monitoring produces around 9,000 samples annually requiring more than 24,000 radiological measurements.

Only a light tritium effect is perceptible locally.

6.3. *Quality assurance systems for the environmental monitoring*

The analysis laboratories at CEA Saclay which carry out the environmental monitoring are accredited by COFRAC (French accreditation committee) according to standard NF EN ISO/CEI 17025. They are approved by the French Nuclear Safety Authority to perform environmental radioactivity measurements as part of the National measurement network (decree of July 8, 2008).

Furthermore, CEA Saclay has had an environmental management system in place since 2002, based on continuous improvement of environmental performance, which includes a sustainable development approach, and it has had ISO 14001 certification since 2004.

6.4. *Relevant information not covered by the preceding headings*

In response to the law requiring transparency in nuclear safety matters (law no 2006-686 of June 13, 2006), the CEA Saclay centre compiles an annual public report containing, in particular, the provisions for safety and radiological protection in the INB, as well as the results of measurements of discharges and their impact on the environment. This report is presented annually at a plenary meeting of the local information commission (CLI), an authority for information, dialogue and follow-up, chaired by the President of the Essonne General Council.

6.5. Summary evaluation

Criterion	Evaluation
MTD/MPE indicators	
Downward trends in the concentrations	Effective downward trend
Relevance of the environmental monitoring programme	Relevant programme redefined by a prefectural decree of 25/09/09
Relevance and reliability of the quality assurance systems	Appropriate and reliable systems
Comprehensive nature of the data communicated	Yes
Reasons for variation compared to the indicators	Not applicable
Uncertainties	Determined
Other information	Not applicable

7. IONISING RADIATION DOSES RECEIVED BY THE PUBLIC

The local impact of liquid discharges is very low. It is estimated from several scenarios:

- it would be of order 1 µSv/year for individuals from a local company who consumed 2 litres of underground water each day in which the tritium concentration had attained a value of order 100 Bq/L because of former contamination. However, no underground water has been captured for human consumption since October 2006;
- it would be of order 0.2 µSv/year, essentially due to the carbon-14 concentration in fish, for fishermen who consumed 8 kg annually of fish caught in the new pond at Saclay. However, all fishing is forbidden in the adjoining pond (the old pond at Saclay) which is an ornithological reserve;
- and it would be less than 0.01 µSv/year for farmers who consumed cultivated products that were irrigated using the subterranean groundwater.

The impact of these liquid discharges for the English Channel is even less. Given that the mean flow entering the ponds at Saclay is order 0.05 m^3/s and that the mean flow at the mouth of the Seine is around 2,500 m^3/s, it can be deduced that there is a dilution factor of order 50,000. The effect on concentrations of radionuclides discharged by the CEA Saclay centre is therefore very low compared to the concentrations of the same radionuclides already present in the waters of the North Atlantic, which come from the fallout of worldwide airborne nuclear tests.

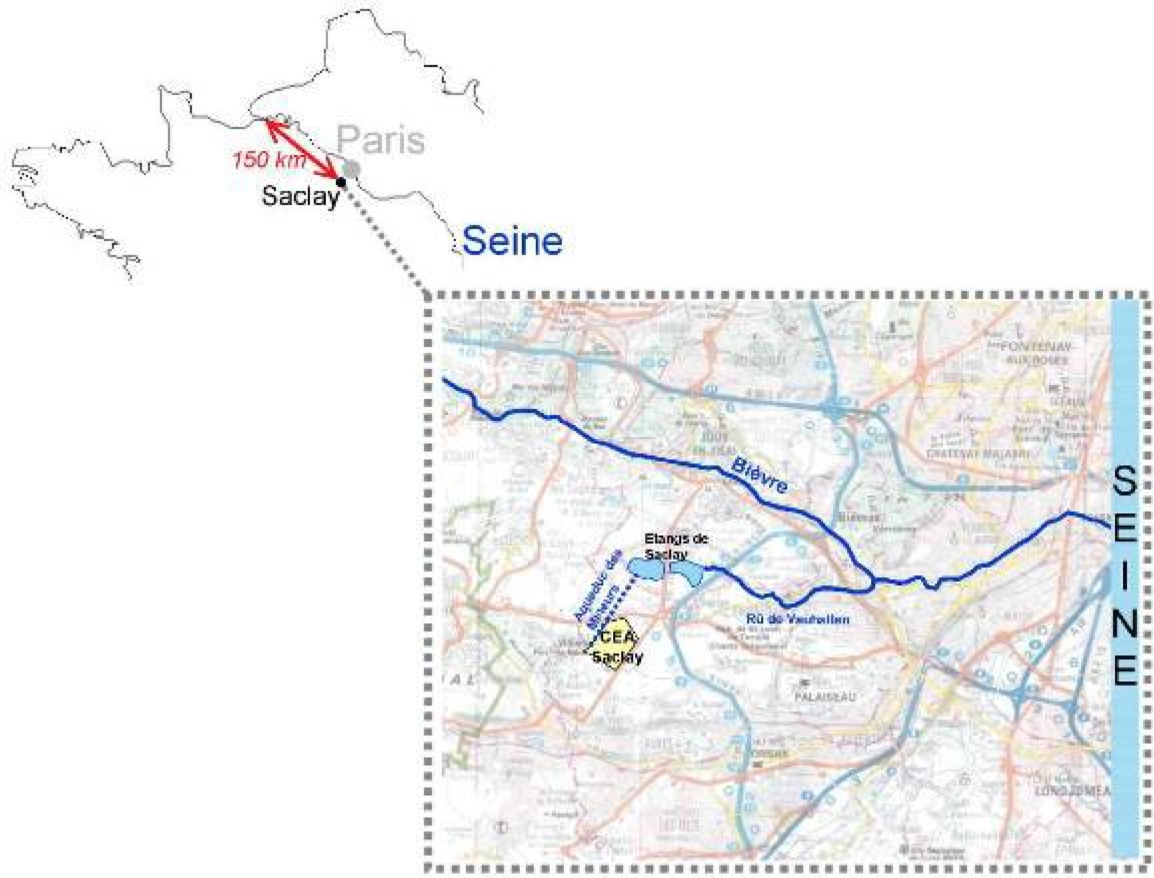
Radionuclides	Order of magnitude of CEA Saclay contribution to levels in the Channel	Order of magnitude of the concentrations found in the North Atlantic	Fractional contributions from CEA Saclay up to the point of their dilution by the Seine into the Channel
H-3	≈ 5.10^{-4} Bq/L	≈ 0.1 Bq/L	≈ 1/200th
Cs-137	≈ 10^{-7} Bq/L	≈ 10^{-3} Bq/L	≈ 1/10,000th
Pu-239+240	≈ 10^{-10} Bq/L	≈ 10^{-6} Bq/L	≈ 1/10,000th

This demonstrates that there is a non-detectable and completely negligible impact from CEA Saclay on the waters of the Atlantic.

Furthermore, based on a hypothetical consumption of 2 litres of water daily, taken from the Seine as it flows into the English Channel, the increased impact due to liquid discharges from CEA Saclay would be less than 0.0001 µSv/year.

APPENDIX A

LOCATION OF THE CEA SACLAY CENTRE



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OSPAR's vision is of a clean, healthy and biologically diverse North-East Atlantic used sustainably

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