2009

National Inventory of Radioactive Materials and Waste

In summary

ANDRA
Mastering radioactive waste

The Inventory is also...

This summary is the version of the *National Inventory* produced for the general public. This *National Inventory* also includes technical documents describing a collection of information on radioactive materials and waste:

Synthesis Report

This report provides a detailed description of all French radioactive materials and waste, current and future, by management sector, activity sector, economic sector owner, etc.

The catalogue of waste families

This is a description of all radioactive waste arranged by family, each one grouping together various kinds of waste with similar characteristics.

The Geographical Inventory

Location of radioactive waste present on French Territory.

All these documents can be downloaded or ordered at www.andra.fr

The National Inventory
a reference tool

A transparent, consistent and safe management of radioactive waste requires understanding such waste, by having as complete and exhaustive a vision as possible of its nature, quantity and location on French territory.

All French producers of radioactive substances have subscribed to this approach for many years. The December 30th 1991 Waste Act entrusted Andra with the task of performing a census of all radioactive waste, present on French territory. This census was carried out using a wide range of sources, notably based on declarations from the producers and holders of such waste. At the beginning of this decade, the government decided to extend the boundaries of the inventory.

So in 2004, Andra issued the first version of the *National Inventory*, a genuine reference tool for radioactive waste management, produced under the supervision of the public authorities.

The mission given to Andra for the inventory was confirmed by the June 28th 2006 Planning Act. This Act entrusts Andra to "*establish, update every three years, and publish the* Inventory of radioactive materials and waste*, existing in France, as well as its location on the national territory*".

The 2009 edition of the *National Inventory* describes the waste that existed at December 31st 2007, and presents forecasts for the quantities of waste expected by 2020 and 2030. The *National Inventory* also describes the radioactive materials which could be recycled, accounted for separately and according to their particular nature.

As responsible for public information on waste and its management, Andra wished to make it available, to the greatest number of people, in a summary version of the *National Inventory*, which aims to be as accessible as possible. As each new edition evolves in response to readers comments on the previous edition, you are invited to leave your comments and suggestions on the Andra internet site at www.andra.fr.

François-Michel GONNOT
Chairman of Andra

Marie-Claude Dupuis
Chief Executive Officer

radioactive waste

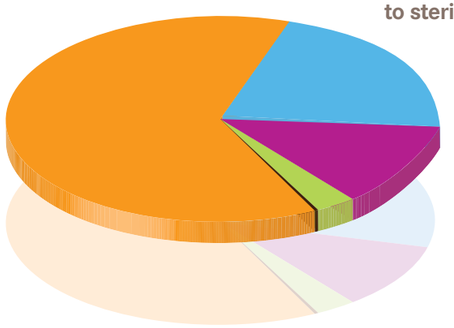
What is radioactive waste ?

All human activities produce waste. Some sectors use the properties of radioactivity and, therefore, produce waste which is radioactive in some cases. Such residues contain substances which, because they emit radiation, could represent a risk to man and the environment. This is why they need to be specifically managed.

Where does it come from?

In France, the majority of radioactive waste comes from the nuclear power industry and the activities of the CEA (Atomic Energy Commission). Numerous other sectors also generate radioactive waste, such as non-electronuclear industrial activities, which use naturally radioactive materials, and research in the fields of chemistry, biology (cell studies), geology, archaeology (dating), medicine (diagnosis and treatment of cancers), defence and even food preservation. Radioactive materials are used to control metal welding, to sterilize medical equipment and in fire detection.

Estimate of the volume distribution of radioactive waste existing in France at the end of 2007 by economic sector



Nuclear power industry	62%
Research	17%
Defence	17%
Industry apart from nuclear power	3%
Medical	1%

Various kinds of waste

Radioactive waste is divided into five categories (or management solutions):

- very-low-level waste (VLLW)
- low-and intermediate-level short-lived waste (LILW-SL)
- low-level long-lived waste (LLW-LL)
- intermediate-level long-lived waste (ILW-LL)
- high-level waste (HLW)

There are various kinds of radioactive waste. The characteristics differ from one waste product to another: physical and chemical nature, level and type of radioactivity, etc. In order to look after these waste products and to design repositories suitable for their level of hazard and its evolution over time, radioactive waste is divided into various categories. In France, this classification of radioactive waste is based on several parameters, in particular:

The level of radioactivity: this is generally expressed in Becquerels (Bq) per gram. Also referred to simply as activity, the level of radioactivity corresponds to the quantity of radiation emitted by the radionuclides (radioactive atoms) contained in the waste.

The radioactive half-life or period associated with each radionuclide that it contains. This period may be expressed in years, days, minutes or seconds. It is defined as the time after which the initial activity of a given radionuclide has halved. We discriminate radioactive waste according to the period of main radionuclides it contains: short half-life (≤ 31 years) and long half-life (> 31 years*).

Other criteria, such as chemical composition for example, can have an impact on waste classification.

*The limit of 31 years was determined from the radioactive half-life of caesium-137 (30.05 years). It concerns an easily measurable fission product, representative of all of the fission products contained in the radioactive waste.

Controlled management

Like many other countries, France has chosen disposal as its long-term management solution for radioactive waste. In France, the French National Radioactive Waste Management Agency (Andra) has been given responsibility for designing and operating disposal facilities. These facilities aim at providing sustainable confinement for substances contained in the waste, over the timeframe required for their radioactive decay. Today, there are surface repositories for VLLW and LILW-SL, which represents nearly 90% of the total volume of French radioactive waste. For the other types of waste (LLW-LL, ILW-LL and HLW), suitable repositories are currently being studied. Meanwhile, such waste is being stored in specific facilities.

Conditioning

To be accommodated in a storage or disposal facility, radioactive waste must meet technical criteria defined by Andra. Once produced, waste is treated (by compacting, incineration, evaporation, etc.) notably in order to reduce volume and/or to stabilize the chemical products it contains.
After treatment, it is conditioned, i.e. usually embedded in a solid and stable material and then packaged in metal or concrete containers. The completed assembly, waste-embedding-container, is commonly referred to as a waste package. The largest generators of radioactive waste, EDF, AREVA and CEA, take care themselves of their own waste conditioning. Each producer remains the owner of its own waste, even after delivery to Andra.

Transport

Radioactive waste packages are transported by rail or road, using containers which meet the strict regulatory requirements relating to transport of hazardous materials.

Each country is responsible of its own waste

French legal framework forbids the disposal of foreign radioactive waste in France.

The safety of a repository relies on a number of combined factors, according to waste type:

- the package containing the waste
- the repository structures in which the packages are placed
- the geology of the site which constitutes a long-term perennial natural barrier

Big-bag of very-low-levelwaste (VLLW)

A concrete drum for LILW-SL

Radium bearing waste drums make up part of the LLW-LL

A drum of vitrified HLW

Hulls and end-caps from nuclear fuel make up part of the ILW-LL

volumes
today and tomorrow

At the end of 2007, there was around 1,153,000 m³ of radioactive waste in France.

In the *National Inventory* quantities of radioactive waste are presented in "equivalent conditioned cubic metres" (m³), i.e. as a volume which represents each waste type once conditioned.

Today

These volumes correspond to the waste that existed on December 31st 2007.

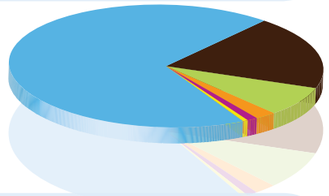
Volumes of radioactive waste, in storage or disposal facilities, at the end of 2007, in equivalent conditioned m³

	Volumes (m³)
VLLW	**231,688** (of which 89,331 is in repositories)
LILW-SL	**792,695** (of which 735,278 is in repositories)
LLW-LL	**82,536**
ILW-LL	**41,757**
HLW	**2,293** (of which 74 is spent fuel)
Management solution to be defined*	**1,564**
Total	**1,152,533** (of which 824,609 m³ is in repositories)

*The waste listed under the heading "management solution to be defined" is waste that the producers have declared without attributing it to an existing management solutions or to one being currently developed. It concerns waste either in a chemical or physical form which does not currently allow it to be considered with one of these solutions, or because no reprocessing method is currently envisaged.

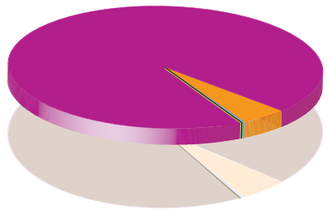
Distribution, at the end of 2007, of the volume of radioactive waste, by radioactive waste type, produced in France

LILW-SL	**68.8%**	HLW	**0.2%**
VLLW	**20.1%**	ILW-LL	**3.6%**
LLW-LL	**7.2%**	Not defined	**0.1%**



Distribution, at the end of 2007, of the level of radioactivity, by radioactive waste type, produced in France

HLW	**94.98%**	VLLW	**0.000 003%**
ILW-LL	**4.98%**	LLW-LL	**< 0.009%**
LILW-SL	**< 0.03%**		



The inventory of radioactive waste is compiled by Andra on the basis of declarations from each waste generator and holder (nature, conditioning, quantity, etc.). In France, there are around a thousand of these, all sectors being included (EDF, AREVA, CEA with its civil and defence activities, research laboratories, hospitals, industry, etc.).

And tomorrow?

The forecasts which are based on hypotheses and scenarios for future energy requirements, present the volume of radioactive waste which will be produced between now and 2020 or 2030. They rely, in particular, on the hypothesis of continued nuclear power generation and on specific scenarios for each of the other activity sectors responsible for producing radioactive waste..

Forecast quantities of stocks of radioactive waste by the end of 2020 and 2030 including all sectors of activity

	2020 Volumes: in disposal or storage facilities	2030 Volumes: in disposal or storage facilities
VLLW	**629,217**	**869,311**
LILW-SL	**1,009,675**	**1,174,193**
LLW-LL	**114,592**	**151,876**
ILW-LL	**46,979**	**51,009**
HLW	**3,679** of which 74 is spent fuel	**5,060** of which 74 is spent fuel
Total	**1,804,142**	**2,251,449**

Developments since the 2006 edition of the *National Inventory*

Changes in the volumes of radioactive waste, in comparison to volumes presented in the 2006 edition, are obviously explained by addition of the volumes produced during the years 2005, 2006 and 2007. However, a reduction has been recorded in the volume of certain categories of waste in comparison to stocks listed in 2006, despite an additional three years of production.
This is the case for waste categories LILW-SL and ILW-LL, notably because of developments in conditioning methods which have enabled a volume reduction or because of changes in the classification of some types of waste.

Volumes to be considered when designing repositories

It is essential to know the quantity and volume of radioactive waste in order to design the storage and disposal facilities. For this purpose, Andra has developed, in association with waste producers, modeling for inventory dimensioning. These models include, in terms of volume, the necessary margins for designing disposal facilities according to future technical evolutions.

classifying waste for better management

For each disposal facility, Andra will issue a set of technical criteria to be met by waste packages in order for them to be accepted. When radioactive waste is produced, it is assigned to a specific waste category according to these various criteria and not only the half-life or the level of radioactivity of the substances it contains. Waste is therefore also, classified as a function of its conditioning and the disposal mode to which it corresponds.

Classification of French radioactive waste as a function of their management

	Very-short-lived (VSL) radioactive half-life <100 days	Short-lived (SL) radioactive half-life ≤31 years	Long-lived (LL) radioactive half-life > 31 ans
Very-Low-Level Waste (VLLW)		**VLLW** disposed of at the CSTFA facility located in the Aube district.	
Low-Level Waste (LLW)	**VSLW** Managed first trought on-site decay and then disposed of as conventional waste.	**LILW-SL*** Disposed of at the CSFMA facility located in the Aube district, which took over from the CSM facility (Manche district) today monitoring in post-closure phase	**LLW-LL** Near-surface repository (between 15 and 200 metres), under development. Commissioning planned for 2019.
Intermediate-Level Waste (ILW)			**ILW-LL** Deep disposal, at 500 metres, under development. Commissioning planned for 2025.
High-Level Waste (HLW)		**HLW** Deep disposal, at 500 metres, under development. Commissioning planned for 2025.	

Lifetime

*** Certain waste when it contains a too large amount of tritium (radioactive hydrogen) must be stored before disposal in order to allow for the decay of this tritium (approximately 12-year half-life).**

Disposal figures
At the end of 2007, more than 70% of radioactive waste is disposed of in repositories. 11% is currently stored awaiting creation of a suitable repository.

Very-short-lived waste (VSLW)

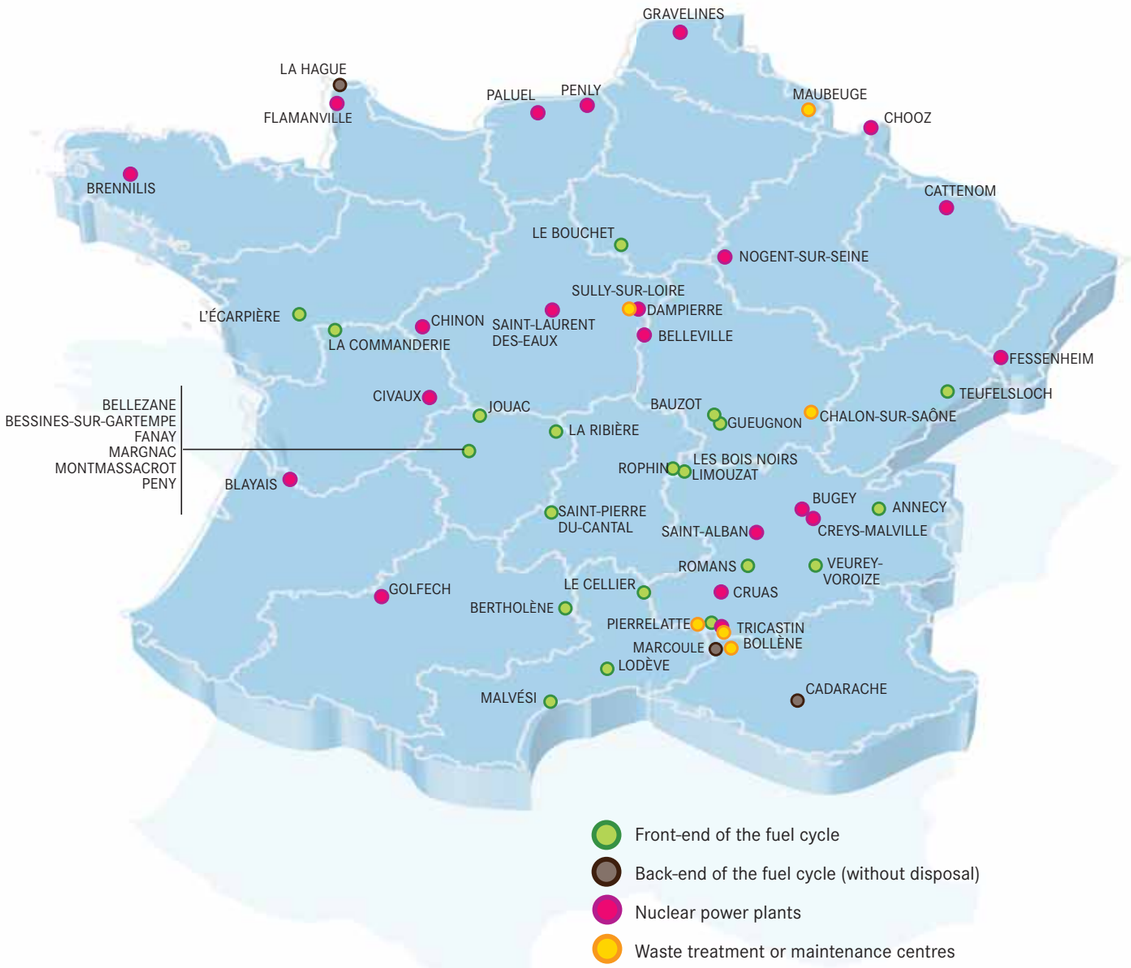
This is mainly hospital waste, containing very-short-lived radionuclides (i.e. with half-lives that are less than 100 days), used for diagnostic or therapeutic purposes. Because of their very short half-lives, this waste is stored temporarily on site, for a period ranging from several days to several months and long enough for their radioactivity to decay. It is then disposed of as conventional waste.

Radioactivity: a phenomenon which decreases
Because radioactivity decays over time, it is considered that short-lived waste does not represent generally a risk after 10 times their half-life, hence around 300 years.

the geographic location of waste

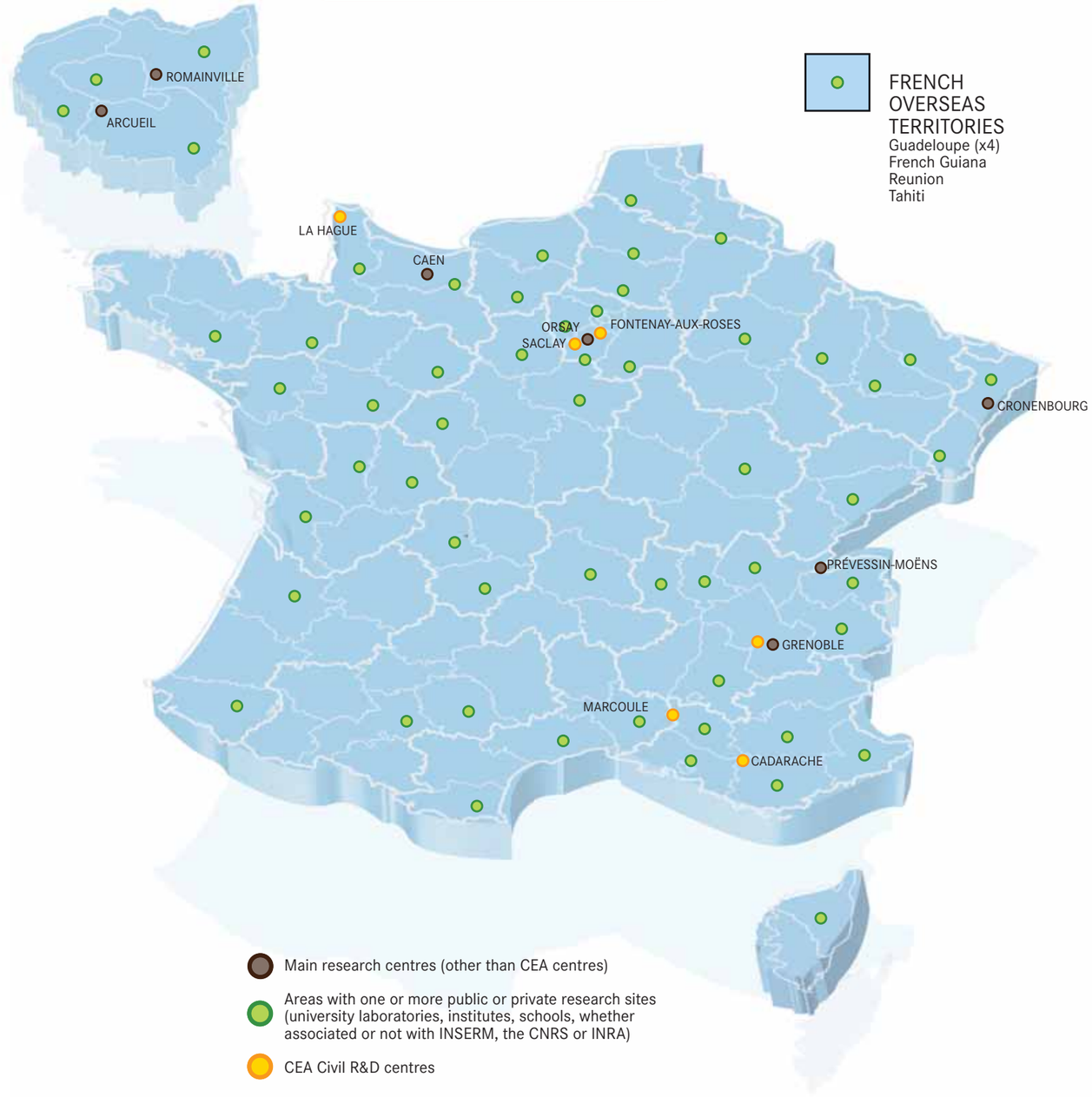
At the end of 2007, there were **1,121 registered sites** on which radioactive waste was located. **More than 90%** of the radioactivity from this waste is concentrated on the sites of **La Hague** in the Manche district and of **Marcoule** in the Gard district.

Main electronuclear sites



- Front-end of the fuel cycle
- Back-end of the fuel cycle (without disposal)
- Nuclear power plants
- Waste treatment or maintenance centres

Main research sites



- Main research centres (other than CEA centres)
- Areas with one or more public or private research sites (university laboratories, institutes, schools, whether associated or not with INSERM, the CNRS or INRA)
- CEA Civil R&D centres

the geographic location of waste

Main defence and nuclear deterrent forces sites

Main defence sites: French Arms Procurement Agency, Armed Forces Health Services, Armed Forces

Research, production or experimentation centres working for the nuclear deterrent

Main storage and disposal sites

Andra repositories

Legacy repositories (see p.26/27)

Storage facilities

Number of sites identified by activity sector:

Front-end of the fuel cycle: **31**
Nuclear power plants: **26**
Back-end of the fuel cycle: **4**
Waste treatment or maintenance centres: **8**
Civil R&D centres of the CEA: **13**
Research centres (excluding the CEA): **569**
Medical activities: **264**
Miscellaneous industrial activities: **42**
Non-nuclear industries using naturally-occurring radioactive material: **14**
Research, production or experimentation centres of the nuclear deterrent forces: **11**
Defence sites: **106**
Storage and disposal facilities: **33**

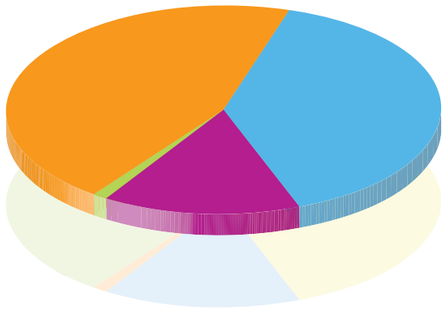
very low-level waste (VLLW)

What is VLLW?

Very-low-level waste mostly comes from dismantling of nuclear facilities and conventional industrial plants in various sectors (chemicals, metallurgy, energy production, etc.) which used naturally radioactive materials. It also originates from clean-up and rehabilitation operations on sites which were formerly polluted by radioactivity. Around 50% of this waste is "common industrial waste" (scrap metal and plastics), 40% is inert waste (concrete, bricks, earth, rubble, etc.) and 10% is "special waste" made of materials such as sludge and, in some cases, pulverulent waste (ashes, etc.). Very-low-level waste has a radioactivity level close to that of naturally occurring radioactivity (between 1 and 100 Bq/g). It contains short-lived and/or long-lived radionuclides. This waste is managed at the Andra CSTFA disposal facility located in the Aube district.

Industrial VLLW (scrap metal and plastics, etc.) before conditioning

Distribution of the volume of VLLW by economic sector at the end of 2007



Nuclear power industry	**44.8%**
Research	**39.5%**
Defence	**14.7%**
Non-nuclear industry	**1%**

Arial view of the disposal facility for very-low-level radioactive waste (CSTFA)

Treatment and conditioning

Before being disposed of, some VLLW is subject to special processing. Plastic and metallic waste is compacted to reduce its volume. Liquid waste, such as contaminated water or sludge, is solidified and then stabilised. Because of the nature of this waste and its low level of radioactivity, it is packaged in metal drums or "big-bags", primarily to facilitate its handling.

On December 31st 2007, there was **231,688 m³** of VLLW. The *National Inventory* predicts a stock of **629,217 m³** of VLLW by 2020 and **869,311 m³** by 2030.

VLLW in a big-bag

Management

Since 2003, very-low-level waste has been disposed of at the Andra CSTFA disposal facility, the first disposal facility in the world for this type of waste.
Situated in the Aube district, it is designed to accommodate 650,000 m³ of waste. Once conditioned, waste batches are labelled and emplaced in successive horizontal layers (around ten on average) inside several metres deep disposal vaults excavated in clay. Once the disposal vault is filled, it is definitely closed and then capped with a compacted clay layer. This compaction process aims at restoring its initial low-permeability to the clay material. In order to get the most out of the repository capacity and reduce volumes to be disposed of, waste generators must take action to optimize waste processing and conditioning.

At the end of 2007, 89,331 m³ of VLLW has already been disposed of at the CSTFA.

VLLW repository cell

VLLW existing at the end of 2007:

20.1% of the total volume of French radioactive waste

0.000 003% of the total radioactivity of French radioactive waste

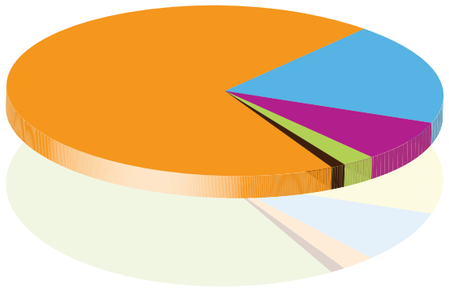
low- and intermediate-level short-lived waste (LILW-SL)

What is LILW-SL?

Low- and intermediate-level short-lived waste mostly comes from the nuclear power industry and the activities of the French atomic energy commission (CEA). It also includes waste from hospitals, research and university laboratories. It may also result from clean-up and dismantling operations. It essentially includes waste related to maintenance (clothes, tools, gloves, filters, etc.) and to the operation of nuclear facilities, such as treatment of gaseous and liquid effluents. This waste contains short-lived radionuclides, such as cobalt-60 and caesium-137, and may also contain strictly limited amounts of long-lived radionuclides. This waste is managed at the Andra CSFMA waste disposal facility located in the Aube district.

Technological LILW (paper, vinyl, cotton, etc.) before conditioning

Distribution of the volume of LILW-SL by economic sector at the end of 2007



Nuclear power industry	69.4 %
Research	19.1 %
Defence	8.1 %
Industry apart from Nuclear power	2.4 %
Medical	1 %

Disposal of an LILW-SL package in a cell at the waste disposal facility for short-lived, low- or intermediate-level waste (CSFMA)

Treatment and conditioning

Before disposal, LILW-SL may be compacted to reduce its volume, or solidified if it is a liquid. Usually, it is placed in metal or concrete containers and then embedded in concrete. Thus, a package of LILW-SL is composed of 15 to 20% radioactive waste and 80 to 85% embedding matrix.

Compacting a drum of LILW-SL

Aerial view of the disposal facility for short-lived, low- and intermediate-level waste (CSFMA)

The CSFMA took over from the Manche waste disposal facility (CSM). It was the first French disposal facility and, from 1969 to 1994, accepted 527,225 m³ of waste. Today this facility is closed and is subject to regular monitoring

On December 31st 2007, there was **792,695 m³** of LILW-SL. The *National Inventory* predicts a stock of **1,009,675 m³** of LILW-SL by 2020 and **1,174,193 m³** by 2030.

Management

Since 1992, low- and intermediate-level short-lived waste has been disposed of at the Andra CSFMA waste disposal facility. Situated in the Aube district, it was designed to accommodate 1,000,000 m³ of waste. Waste is disposed of at surface in reinforced concrete cells, 25 metres square and 8 metres high. Once filled, these cells are closed with a concrete slab and then sealed with an impermeable coat. Finally, the cell will be capped with a several metres thick layer of clay, to ensure the long-term confinement of the waste.
Some LILW-SL cannot be managed in its current state at the CSFMA and is meanwhile stored in producers' facilities. In particular, this concerns highly tritiated waste.

At the end of 2007, 208,053 m³ of LILW-SL has already been disposed of at the CSFMA. Furthermore, 527,225 m³ of LILW had been disposed of at the CSM before its closure.

LILW-SL existing at the end of 2007:

68.8 % of the total volume of French radioactive waste

< 0.03 % of the total radioactivity of French radioactive waste

low-level long-lived waste (LLW-LL)

What is LLW-LL?

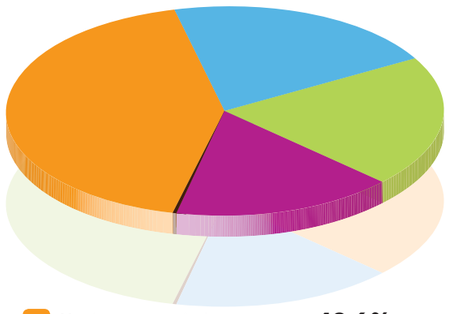
Low-level long-lived waste is mainly "radium-bearing" waste and waste termed "graphite" because it contains this element, a very pure form of carbon. Radium-bearing waste comes from processing of various minerals used, for example, in fine metallurgy. Graphite waste is generated during dismantling of first generation nuclear reactors (graphite-moderated gas-cooled reactors), which have now been decommissioned. There are other sources of LLW-LL, such as old radioactive objects (radium fountains...), sealed sources (lightning conductors, fire detectors, etc.). There is also some bituminised waste in this category. In most cases, production has either ceased or must cease shortly. LLW-LL contains, mostly, long-lived radionuclides. Disposal for this type of waste is currently under study.

A graphite sleeve surrounding the fuel used in first generation nuclear reactors

Radioactive lightning conductor head

A radioactive fire detector

Distribution of the volume of LLW-LL by economic sector at the end of 2007



Nuclear power industry	**42.6 %**
Research	**20.5 %**
Industry apart from Nuclear power	**20.4 %**
Defence	**16.5 %**
Medical	**0.03 %**

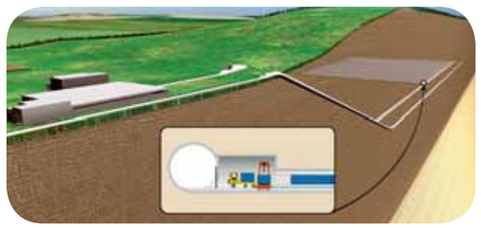
Treatment and conditioning

Conditioning of LLW-LL has been developed over several years and is making gradual progress. At the present time, it is planned to emplace graphite waste in metal baskets which are then put into concrete containers. Cement would then be injected in the container, to be completely closed with a concrete lid.
On the other hand, some radium-bearing waste is already packaged in metal drums. To facilitate handling of these packages, it is planned to group them into metal containers. Other radium-bearing waste, presently stored in bulk, would be placed directly in metal containers.

Radium-bearing waste packaged in drums

Management

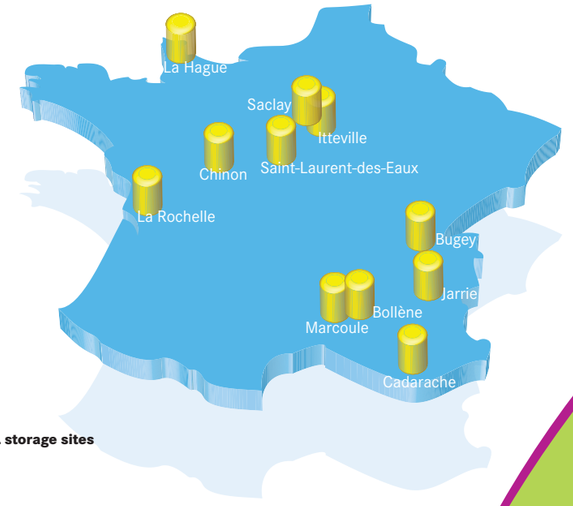
As prescribed by article 4 of the June 28th 2006 Planning Act, Andra has been studying the concept of shallow disposal, between 15 and 200m underground, for this category of waste. The outcome of this study is the commissioning of a repository by 2019, subject to government approval.



Schematic diagram of one LLW-LL disposal concept currently being studied

LLW-LL storage

Pending the creation of a suitable disposal facility, existing LLW-LL waste is stored at the production sites or in facilities which have traditionally used radioactive applications.



LLW-LL storage sites

On December 31st 2007, there was **82,536 m³** of LLW-LL.
The *National Inventory* predicts a stock of **114,592 m³** of LLW-LL by 2020 and **151,876 m³** by 2030.

LLW-LL existing at the end of 2007:

7.2% of the total volume of French radioactive waste

< 0.009% of the total radioactivity of French radioactive waste

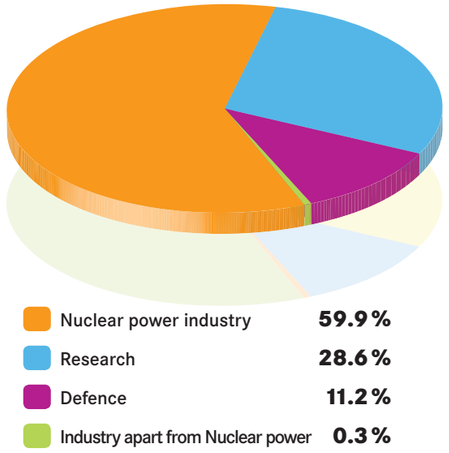
intermediate-level long-lived waste (ILW-LL)

What is ILW-LL?

The fuel used to operate current nuclear reactors is composed of a uranium assembly sometimes with plutonium. Over time, this fuel becomes less efficient. It is then needs recycled, usually at the AREVA plant at La Hague. The metal structures surrounding this fuel are cut into small sections in order to later separate the uranium and plutonium from non-reusable residues. Intermediate-level long-lived waste is mostly composed of these metal structures (cladding, hulls and end caps). It also comes from residues (waste from effluent treatment, equipment, etc.) originating from the operation and maintenance of nuclear facilities. Disposal of this type of waste is currently under study.

Waste metal from the structures surrounding spent fuel (hulls)

Distribution of the volume of ILW-LL by economic sector at the end of 2007



Treatment and conditioning

In order to reduce its volume, a significant fraction of solid ILW-LL is compacted to form pucks which are then transferred into concrete or metal packages. To facilitate future handling, transport, storage and disposal operations, these primary waste packages are due to be packaged in lots of four in concrete disposal containers.

Metal package containing several ILW-LL pucks

ILW-LL disposal container

On December 31st 2007, there was **41,757 m³** of ILW-LL. The *National Inventory* predicts a stock of **46,979 m³** of ILW-LL by 2020 and **51,009 m³** by 2030.

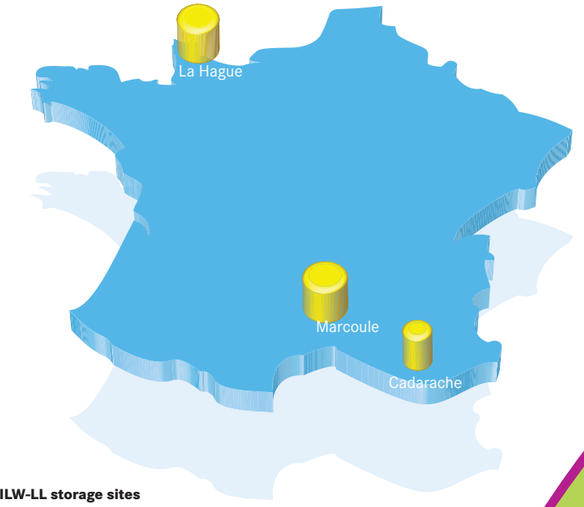
Management

As prescribed by article 3 of the June 28th 2006 Planning Act, Andra is developing, as in the case of HLW, a 500-metre deep disposal concept for ILW-LL. The outcome of this study is the commissioning of a repository by 2025 in Meuse/Haute-Marne, subject to government approval and after a public debate.

Schematic diagram of the deep repository

ILW-LL storage

Pending the commissioning of the deep repository, ILW-LL packages are stored at their production sites, mainly La Hague (AREVA), Marcoule (CEA) and Cadarache (CEA).



Main ILW-LL storage sites

ILW-LL existing at the end of 2007:

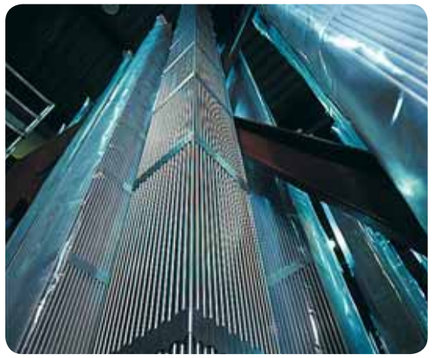
3.6% of the total volume of French radioactive waste

4.98% of the total radioactivity of French radioactive waste

high-level waste (HLW)

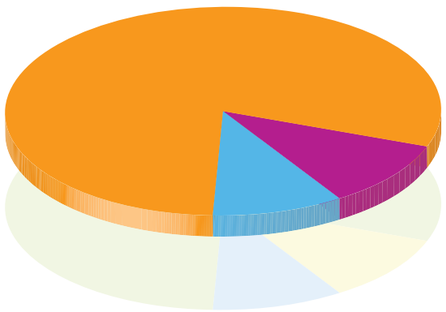
What is HLW?

During recycling, spent nuclear fuel is immersed in a chemical solution which enables the uranium and plutonium to be separated from the non-reusable residues. These highly radioactive residues make up high-level waste. It represents 3 to 5% of the spent fuel and is composed of fission products (caesium-134 and -137 and strontium-90), activation products (cobalt-60) and minor actinides (curium-244 and americium-241). Because of its high radioactivity, some of this waste gives off heat. Disposal solutions for this type of waste are currently under study.



Fuel assembly used in nuclear reactors

Distribution of the volume of HLW by economic sector at the end of 2007



Nuclear power industry	**80.1 %**
Defence	**10.3 %**
Research	**9.6 %**

Treatment and conditioning

High-level waste is stored temporarily in tanks before being calcined in the form of a powder and then incorporated into a molten glass. The mixture is poured into a stainless steel container. The confinement capacity of this special glass matrix is particularly high and durable. A package of HLW contains around 400 kg of glass for 11 kg of waste. To facilitate future handling, transport, storage and disposal operations, each primary package is due to be placed in a steel disposal container.

Molten glass paste

Metallic package for vitrified HLW

On December 31st 2007, there was **2,293 m³** of HLW, of which 74 m³ consisted of spent fuel from research and national defence.
The *National Inventory* predicts a stock of **3,679 m³** of HLW by 2020 and **5,060 m³** by 2030.

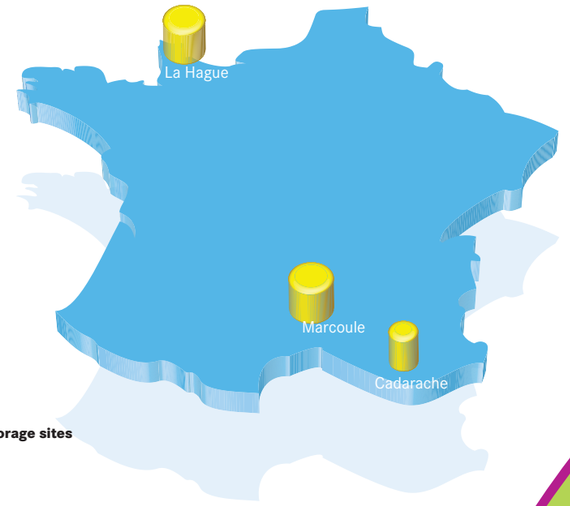
Management

As prescribed by article 3 of the June 28th 2006 Planning Act, Andra is developing , as in the case of ILW-LL, a 500-metre deep disposal concept for HLW. The outcome of this study is the commissioning of a repository by 2025 in Meuse/Haute-Marne, subject to government approval and after a public debate.

Schematic diagram of the deep repository

HLW storage

Pending the commissioning of the deep repository, HLW is stored at production sites, La Hague (AREVA), Marcoule (CEA) and Cadarache (CEA).



HLW storage sites

Storage of HLW in ventilated shafts on the AREVA site at La Hague, in the Manche

HLW existing at the end of 2007:

0.2% of the total volume of French radioactive waste

94.98% of the total radioactivity of French radioactive waste

“Legacy” waste

Some radioactive waste, having been disposed of according to methods available at that time, will not be managed by the current disposal facilities such as we know them today. Therefore, such waste is listed in the *National Inventory* but is not considered in the statement describing waste volumes. There are three types of “legacy” waste:

- **residues left over from uranium ore processing;**
- **waste in “legacy repositories”;**
- **waste dumped at sea.**

Residues from processing of uranium ores left over on former mining sites

The mechanical and chemical processing of ores for uranium recovery generates so-called “processing residues”. They are present in the form of blocks, sand or sludge.
Between 1948 and 2001, uranium mining operations took place at 210 sites in France (uranium exploration, extraction and processing). Once mining has ceased, the residues, estimated at around 50 million tonnes, were left over on, or near to, 20 of these sites. AREVA carries out monitoring operations on and around these former mining sites, under the supervision of the relevant authorities: The Nuclear Safety Authority, the Institute for Radioprotection and Nuclear Safety, Regional Directorates for environment, planning and housing, health and social Authorities, etc.

Bellezane mining site (Haute-Vienne district) while in operation

Bellezane mining site (Haute-Vienne district) once rehabilitated

Waste in “legacy repositories”

There are in all 23 “legacy waste repositories” whose liability does not belong to Andra but to the site owners. These include:

- **12** sites with facilities designed to receive hazardous and non-hazardous waste and which have regularly, or occasionally, received waste containing traces of radioactivity;
- **8** sites generally situated near to nuclear industry facilities or plants where, in the past, radioactive waste was disposed of in mounds, backfill or lagoons;
- **3** atolls in French Polynesia where waste from nuclear tests in the Pacific was disposed of.

Waste dumped at sea

Dumping of radioactive waste was carried out by eight European countries over three decades from the end of the 1940’s. This dumping was originally carried out in shallow territorial waters but was later performed at open sea at great depth. The technique was abandoned in 1982 following the international agreement known as the “London Convention”. France participated to only two dumping campaigns in the Atlantic, in 1967 and 1969, on two separate sites at a depth greater than 4,000 metres.

Sea dumping of radioactive waste in the 1960’s.

sites contaminated by radioactivity

A site is contaminated by radioactivity when radioactive substances have been handled or disposed of, in an uncontrolled manner, causing these substances to be dispersed and presenting potential risks to health and the environment, depending on the activity carried out on the site. When a site has been contaminated by radioactivity, Andra can plan a clean-up operation, upon request either by the owner or the public authorities, when the site is declared orphan (for instance defaulting owner).

Origin of contaminated sites

Most of the contaminated sites are related to past activities, dating from the interwar period, and do not concern the electronuclear industry: radium extraction for medicine and personal hygiene products, manufacture and application of paints for night vision, ore mining, etc. After the war, the memory of these sites, which were generally situated in urban zones, was lost and some of them were reclaimed for use as homes, kindergartens or schools.
Other more recent sites, linked to other activities (thorium, tracer molecules, luminescent paints, etc.) have been left as wasteland and made secure. As strict controls are applied to current facilities, there are relatively few cases of non-compliance to regulatory standards or accidents taking place, which may have led to radioactive contamination.

Approach for the management of contaminated sites

1. Identification of potentially contaminated sites
(observations of terrain, statements from former employees, bibliographic research, etc.)

2. Doubt raising about the radioactive contaminations by the Institute for Radioprotection and Nuclear Safety (IRSN)

3. Operations to secure contaminated sites,
carried out by Andra (fences, walls, signs, bans, etc.)

4. Assessment of the risk presented by the site as a function of its intended use (housing, school, recreation, etc.)

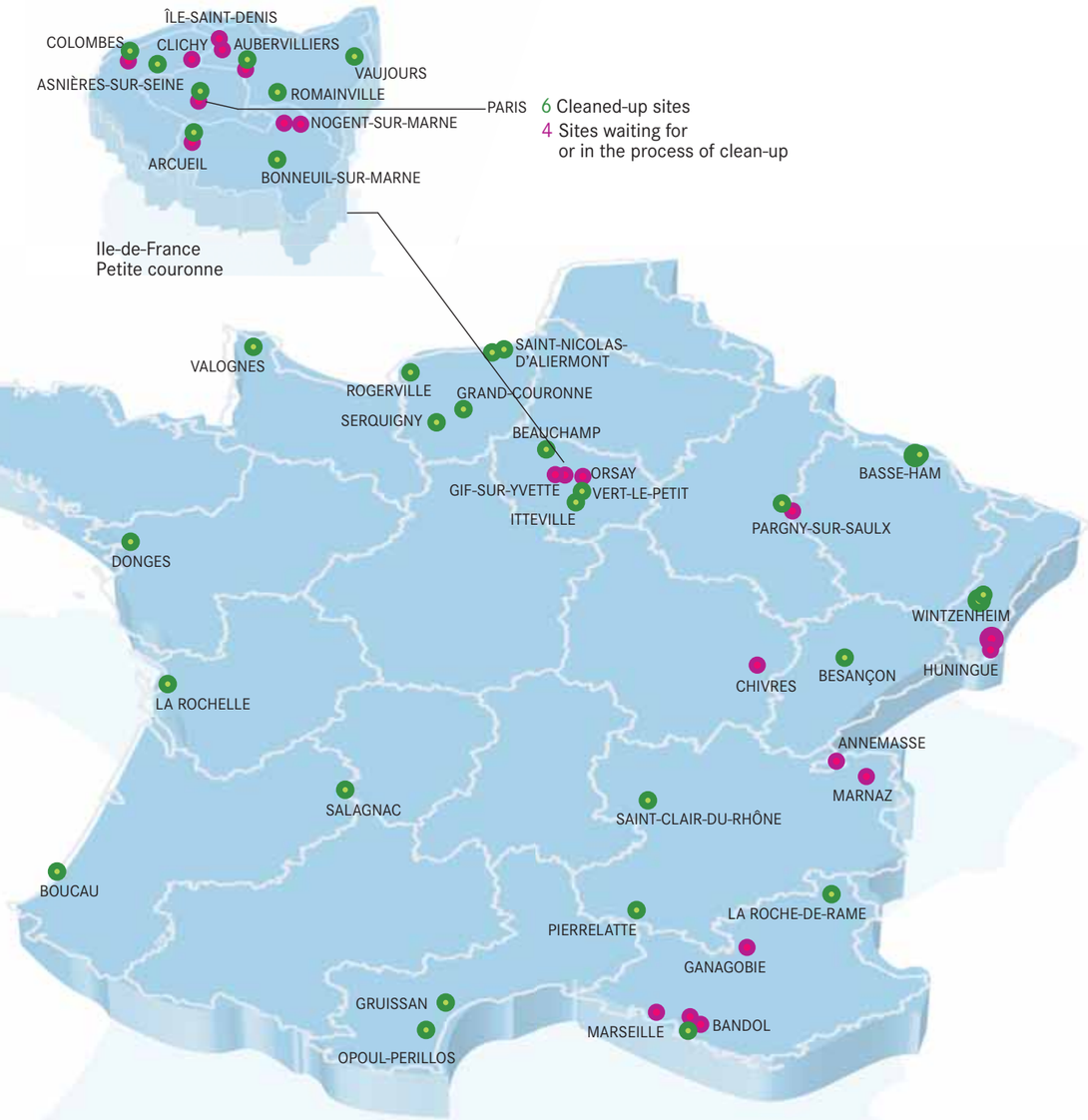
5. Definition of clean-up techniques and strategies
(decontamination techniques, on-site waste management, etc.)

6. Site clean-ups by Andra, which may take several months or several years depending on the site

7. Take-over of radioactive waste resulting from the clean-up (earth, contaminated rubble, etc.)

The clean-up of contaminated sites with a defaulting owner is financed by a state subsidy. The National Commission for Radioactivity Assistance (CNAR) provides advice on the use of this subsidy and on the relevance of site clean-up operations.

Radioactive waste coming from clean-up operations on contaminated sites is mainly VLLW or LLW-LL. It is estimated that the volume of waste generated by clean-up of such sites is around 300 m³ per year.



All in all 60 sites are recorded of which:

- 24 are waiting for or are in the process of clean-up
- 36 sites cleaned up, including 6 where the radioactive waste generated by the clean-up is in storage awaiting removal.

Decontamination works at Gif-sur-Yvette, Essonne district

radioactive objects

At the beginning of the 20th century, shortly after its discovery, the risks linked to radioactivity were still more or less unknown. It was believed that radioactivity would provide "miraculous" benefits for mankind. This enthusiasm for radioactivity rapidly gave birth to the "radium industry" in the inter-war period. Radium was widely used in manufacturing of numerous everyday items and also as a medical and paramedical material: lipsticks, ointments, luminescent alarm clocks, water fountains, needles with radium, etc. Today, these items can be found among personal belongings, in collections, or even lying forgotten in attics; most of the time without their owners being aware of their radioactivity or the risk they present.

Radioactive objects form mainly LLW-LL and VLLW. Around 100 radioactive objects are collected each year by Andra.

What are the risks?

Radioactivity of such objects depends on the type of involved radionuclides and objects. These objects may be contaminated and they may, in turn, contaminate people who touch them. In the majority of cases, the consequences are minor but, when in doubt, it is recommended to address the situation and contact Andra. Direct contact with the objects should be avoided.

In case of doubt,
it is recommended that you **do not handle the objects directly**, but **isolate them** from your everyday environment (by wearing gloves and placing the objects in a plastic bag), **avoid any prolonged contact,** and do not throw away in a dustbin or dump them anywhere but **contact Andra**.

Subsidised and appropriate take-over

Andra provides free, or significantly assisted, take-over for these objects. In this respect, Andra is available to holders of such waste objects to characterise them and implement the relevant resources for their collection. These objects will then be managed in the same way as radioactive waste. If they cannot be accepted in an existing disposal facility, then they will be stored in specific facilities, until a suitable repository is available.

Contact

If you think that you may have such an object at home, contact Andra :
1/7 rue Jean-Monnet
92298 Châtenay-Malabry cedex
Phone: +33 1 46 11 83 27
Mail: collecte-dechet@andra.fr
Website: www.andra.fr

The different types of object

1. Radium-bearing objects for medical applications known as ORUM

Former medical objects, which were used for their radioactive property, they have been preserved as collection items by private individuals, often when there was a radiological doctor in the family. It concerns mainly needles, tubes, cladding and probes, which can emit intense radiation when taken out of their boxes.

2. Paramedical objects

Some paramedical objects were used in the 1920's to enrich fresh water with radon (radioactive gas): radium coffee machines, radium fountains, radon emanators, etc.

3. Minerals

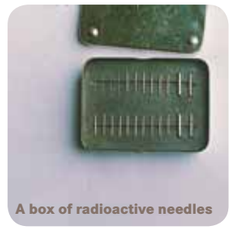
Minerals containing, for example, uranium, polonium or radium. These often concern autunite, pitchblend or monazite, which are found in collections in the homes of geologists or in some colleges.

4. Natural salts

Natural salts containing, for example, uranium, thorium or radium. It concerns notably uranyl acetates or nitrates, uranium or thorium oxides as well as radium nitrates and chlorides. These are kept in old bottles in attics, schools, universities and other laboratories.

5. Former everyday objects

Luminous hands and dials of old time devices such as watches, alarm clocks, compasses and airplane instruments are radioactive. The luminescent effect was obtained by adding radium or tritium to the paint.


A box of radioactive needles


Old luminescent timepieces


Minerals


Compass


Radium fountain


Natural salt

How to recognise a radioactive object ?

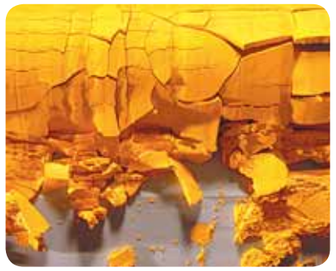
- the presence of a radioactive warning sign on the label (either on the object it self or on its packaging)
- the manufacturing brand or the name of the product written on the label which includes the word radium, uranium or a derivative of these
- an object made before the 1960's, which glows at night without having been exposed to light for at least 48 hours
- the fact that it is packaged in concrete or lead

radioactive materials

Unlike radioactive waste, radioactive materials have the potential to be used, directly or after processing. Some of these, such as plutonium, are already reused. Others are stored awaiting possible future use. Radioactive materials are recorded in the *National Inventory* because some of them could, in the future, be reclassified as radioactive waste if their recovering is no longer planned by the authorities or by their holders. For others, the recycling process could generate radioactive waste.

Natural uranium extracted from a mine

Termed yellow cake, this yellow powder is a uranium concentrate. Uranium, a naturally radioactive metal, is found in rocks and obtained from ores. Today, all of the French mines have been shut down and natural uranium is imported directly from abroad.



***Yellow cake*, uranium concentrate**

Enriched uranium

Enriched uranium is natural uranium enriched with uranium-235, for manufacturing of nuclear reactor fuel.

Depleted uranium

Depleted uranium in uranium-235 is a residue obtained during the natural-uranium enrichment process. It is transformed into a solid, chemically stable, incombustible, insoluble and non-corrosive material, in the form of a black powder.

Depleted uranium canisters at Pierrelatte, Drome

"Recycled" uranium

Recycled uranium is recovered during spent fuel processing at the AREVA plant at La Hague. It can be used to fabricate new fuel.

Boxes of plutonium dioxide at La Hague, Manche district

Plutonium

Plutonium is a radioactive element, artificially generated in nuclear reactors. It is recovered during spent fuel processing, in the same way as uranium, in order to be reused in the fabrication of new fuel. The plutonium stock, relating to military activities, belongs to Classified Defence Information.

Thorium

Rare earth metals (found naturally in the Earth's crust) are extracted from ores such as monazite and used in numerous applications (manufacture of microphones, hi-fi equipment, automotive catalytic convertors, etc.). Processing these rare earth metals generates a by-product, thorium, a radioactive metal which is currently stored pending a possible future use.

Suspended materials

The Rhodia rare earth processing plant at La Rochelle releases chemical waste which is then neutralised by special treatment. Suspended materials, composed of 25% rare earth residues, are recovered and can be reused.

Nuclear fuels being used in reactors and spent fuel

At any time, there are stocks of fuel being used in nuclear reactors and stocks of spent fuel. Spent fuels are stored temporarily in cooling pools, while awaiting decisions on their recycling to recover their uranium and plutonium content.

Before recycling, spent fuel is stored, in pools which facilitate its cooling

Stocks of radioactive material on December 31st 2007 and forecasts for 2020 and 2030

	2007	2020	2030
Natural uranium extracted from mines (tHM)	27,613	32,013	32,013
Enriched uranium (tHM)	3,306	1,764	2,714
Depleted uranium (tHM)	254,820	332,324	452,324
Recycled uranium (tHM)	21,180	36,000	49,000
Plutonium (tHM)	82	55	53
Thorium (t)	9,399	9,399	9,290
Suspended materials (t)	21,672	0	0
Nuclear fuels being used in nuclear power and research reactors and spent fuels (tHM)	4,875	4,590	1,100
Spent fuels awaiting processing	12,887 tHM 183 t	16,894 tHM 230 t	14,974 tHM 298 t

Spent fuels figures awaiting processing are expressed in metric tonnes of Heavy Metal (MTHM) for nuclear power reactors and in tons (t) for research and non-Classified Defence activities.

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2009 EDITION OF THE NATIONAL INVENTORY OF RADIOACTIVE MATERIALS AND WASTE

Synthesis Report

The Geographical Inventory

The Catalogue of waste families

In summary

All of these documents are available on CD-Rom
and on the Andra internet website **www.andra.fr**
where you can also make your suggestions

ANDRA
Mastering radioactive waste

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