

SELECTING THE OPTIMAL STRATEGY FOR

# **ON-SITE RECOVERY AND TREATMENT OF SOIL**

**CONTAMINATED BY PYROTECHNIC, CHEMICAL,  
AND NATURAL RADIOACTIVE COMPOUNDS**



**Since 1994, CURIUM has been dedicated to the management of environmental risks related to hazardous substances, from technical studies to in situ works.**

The CURIUM team is composed of experienced chemical engineers and technical operators who develop and implement solutions for all types of hazardous waste.

**1994** founding year

**50%** engineers in the team

**10** languages spoken by team

**7,6 Mio. €** turnover 2021

**123** projects completed in 2021

**17** countries of intervention





**CURIUM offers a wide range of services for the management of chemical and radiological issues in all sectors.**

### Works on site

- Contamination diagnostics and decontamination operations
- Management of incidents involving hazardous substances
- Management of production change or stoppage involving hazardous products
- Dismantling of facilities
- Hazardous waste management
- etc.

### Studies and engineering

- Assistance to project managers
- Technical expertise
- In-house laboratory for analyses and tests



## Generality - Radiological pollution of soils

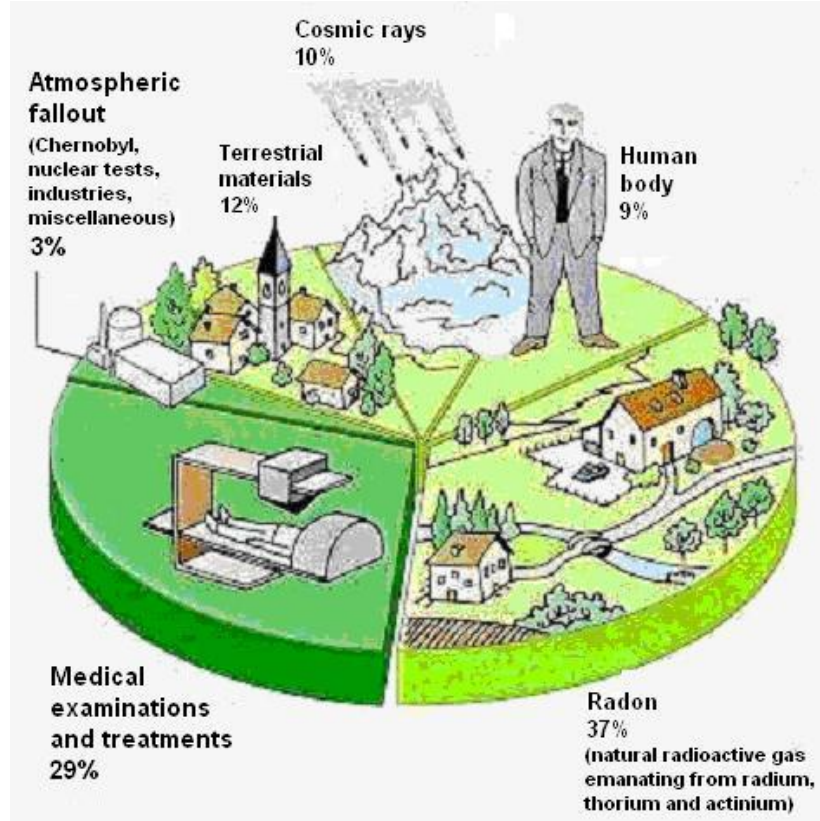
Contamination of the soil with the radioactive pollutants is an important origin of hazard for the environmental and health safety, as well as for the economy. Industrial activity may impact the activity of radionuclides naturally present in the environment.

With regard to radiological contamination of soil, it is necessary to take into consideration:

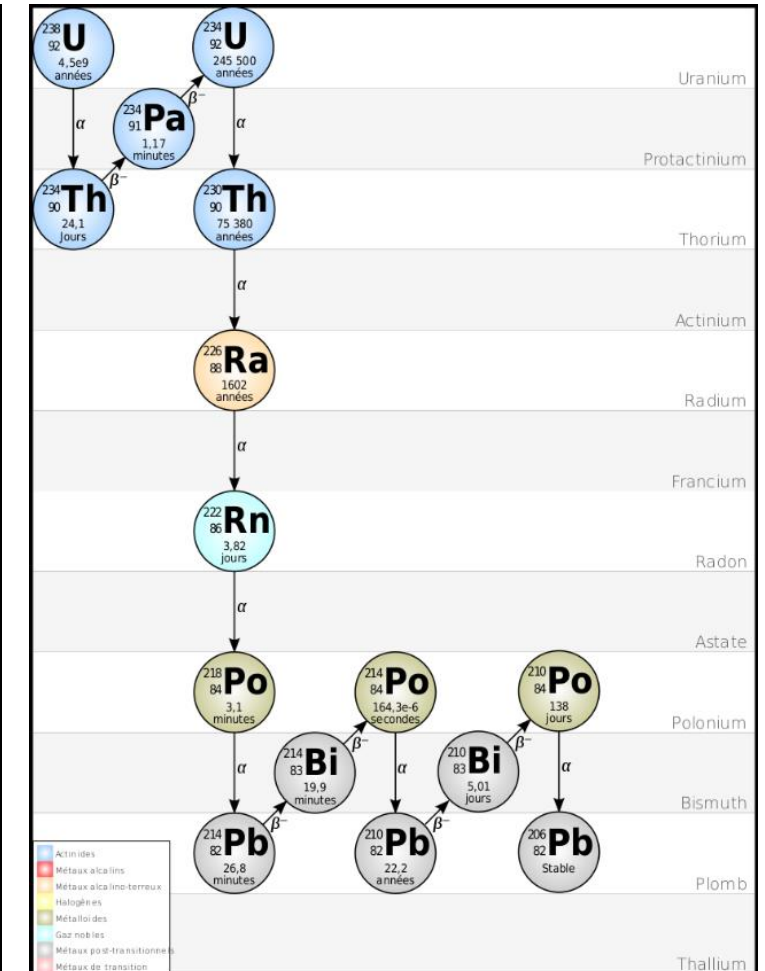
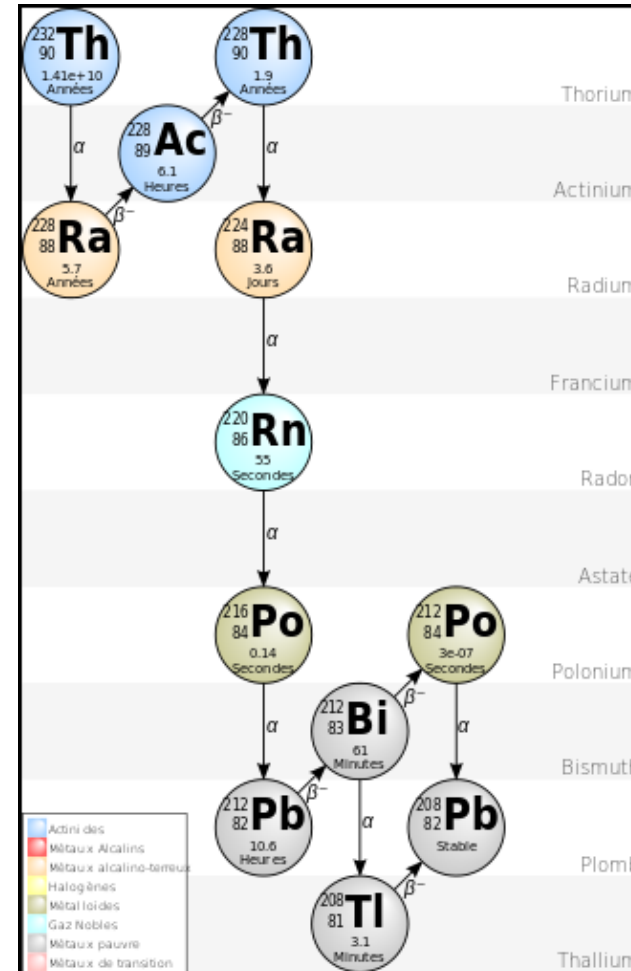
- **Nature of the soil**
- **Volume impacted by pollution**
- **Intensity of pollution and nature of contaminants**
- **Economically and environmentally sound management and remediation options within the legal framework**



# Generality - Naturally Occurring Radioactive Material (NORM)



+ Technologically Enhanced Naturally Occurring Radioactive Material (TENORM): Treatment residuals or products that contain elevated radioactivity which may have unintentionally been formed.



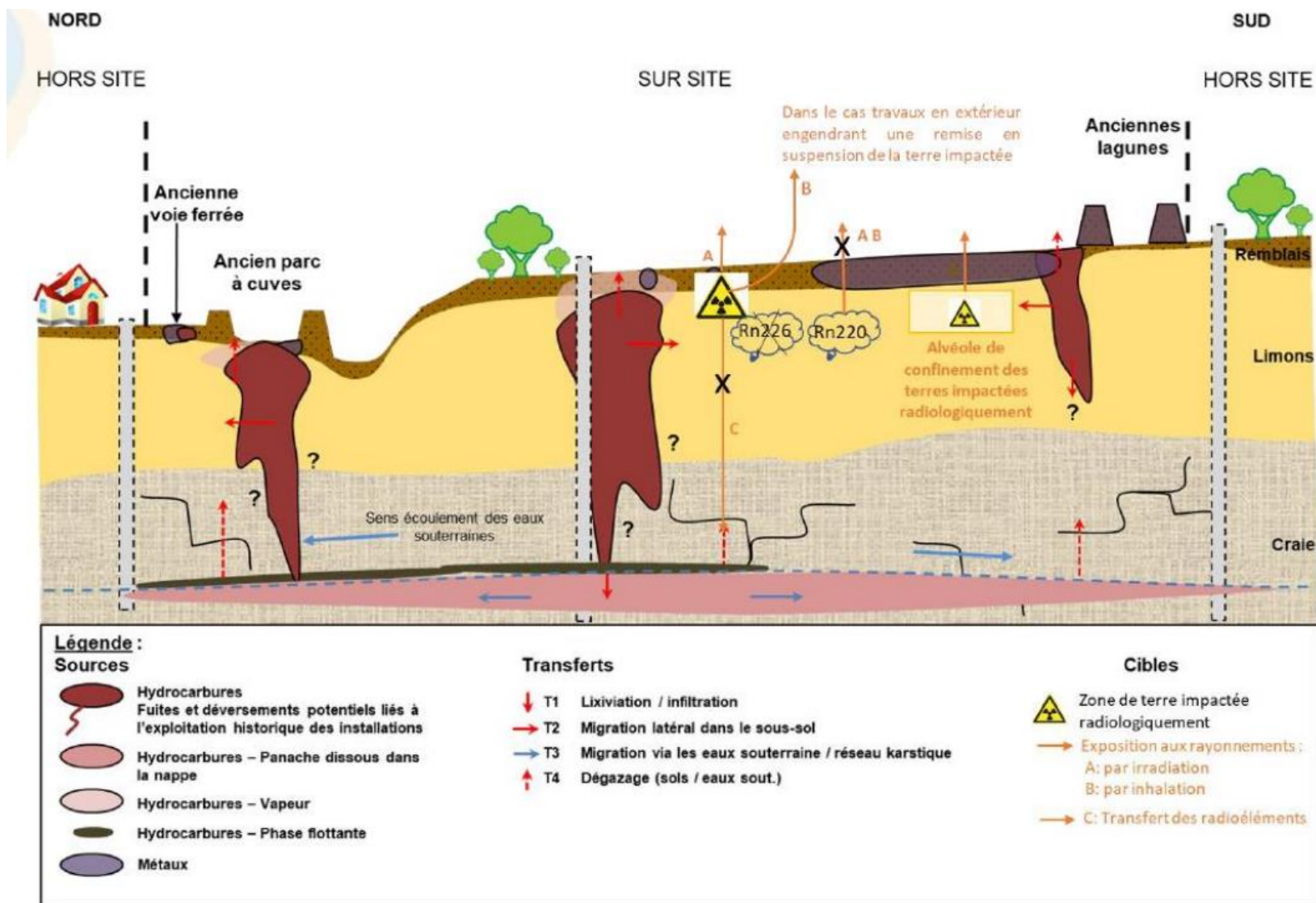


# The issue



- Historical chemical **35-hectare** site (Oil&Gas) with **150 years** of **industrial exploitation**
- **Chemical and pyrotechnic** cross-contamination
- Remediation by **GOLDER** (future use of site: shopping center and park)
- Remediation plan for chemical and pyrotechnical contamination in progress : soil left in place, confined on site and eliminated in an external landfill
- A truck with polluted soil from the site triggered the **radioactivity detection** gantry of the waste treatment facility
- Presence of radioelements of **natural origin (NORM)** revealed
- Based on preliminary estimations, 1350 m3 of soils were impacted by radioactivity
- Radiological activity values of up to 18 Bq/g, Th232 chain

# The issue



Conceptual diagram



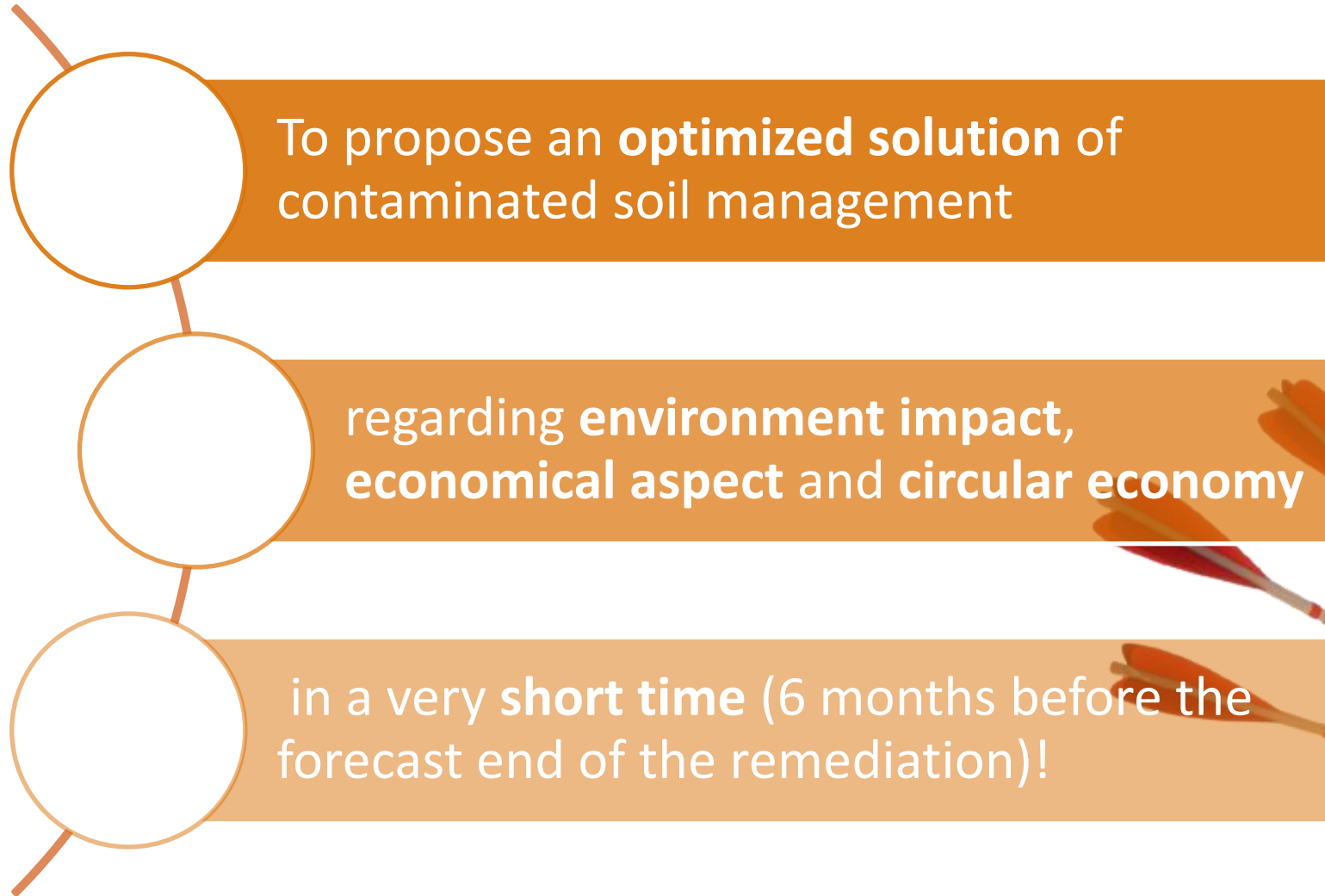
## Legal framework for radioactive soil management

- ✓ When the future use of the site is defined, IRSN (Institute for Radiation Protection and Nuclear Safety – France) provides for a **methodological guide** on the management of radiologically polluted sites and soils (December 2011).
- ✓ This guide proposes a tool for **Quantitative Radiological Exposure Assessment** (in French, “EQER”).
- ✓ The EQER includes an approach to interpret the state of the environment.
- ✓ The result of this assessment must first be assessed in relation to the **reference value of 1 mSv/year**.
- ✓ If the results are incompatible with the activities envisaged on site, a **management plan** has to be elaborated for the polluted soils.
- ✓ Radioactive soil remediation declared to French authority (**DREAL, ASN**)





# The Challenge



# Methodology proposed



- Analysis of input data
  - ✓ Site history documents
  - ✓ Data from remediation company and waste treatment facility
  - ✓ Radiological and chemical measurements on site and in laboratory (COFRAC)
  - ✓ Correlation study
- Adding data's : on site measurement, sampling, laboratory analyses
- Quantitative Radiological Exposure Assessment ("EQER") for excavated soil, in containment
- Quantitative Radiological Exposure Assessment ("EQER") for soil left *in situ*
- ADR transport study
- Analysis of possibility of envisaged future site use (shopping centre / leisure park):
  - ➔ **Maximum permissible risk objective retained at 0.8 mSv/year (French Public Health Code allows for an exposure of up to 1mSv/year)**



## Analysis and findings



- **Radiological data:** Thorium 232 at secular equilibrium, natural thorium chain only, negligible exposure to thoron, source term at ground level only
- **Radiological pollution of the water table is unlikely despite its vulnerability:** the water table is at a depth of 20m, signal emerges at a depth of 1.40 m at the deepest + no consumption of water
- **Radiological on site measurement**
- **Radiological and chemical analyses on laboratory**
- **More than 25K measures realized!**

## The solution – Scenario studied

Scénario étudié	Activité massique tête de chaîne (Bq/g)	Débit d'équivalent de dose ajouté ( $\mu\text{Sv/h}$ )	Modes de gestion	Dose efficace* ( $\mu\text{Sv/an}$ )
Terres excavées – Scénario moyen	2,5	1	Confinement des terres d'une épaisseur de <b><u>20 cm</u></b> minimum	537 $\mu\text{Sv/an}$
Terres excavées – Scénario majorant	18	7,5	Confinement des terres d'une épaisseur de <b><u>50 cm</u></b> minimum	309 $\mu\text{Sv/an}$
Scénario limite ICPE Rubrique 2797 du décret 2018-434 du 4 juin 2018	20	8	Confinement des terres d'une épaisseur de <b><u>50 cm</u></b> minimum	330 $\mu\text{Sv/an}$
Terres laissées en place	1,1	0,42	Terres laissées en place sans recouvrement	469 $\mu\text{Sv/an}$

\*La dose efficace à ne pas dépasser, associée à la limite d'exposition annuelle définie par l'article R1333-11 du code de la santé publique, est de **1000  $\mu\text{Sv/an}$** .



## The solution – Soil management options compared

For all options : soil < 0,42  $\mu\text{Sv/h}$  adding exposure to the background left in place

- **Option 1** : totality of soil > 0,42  $\mu\text{Sv/h}$  eliminated in an external landfill
- **Option 2** : mix solution with on site existing confinement and external landfill
- **Option 3** : mix solution with on site existing confinement and coverage of soil left in place
- **Option 4** : new on site confinement

Considered criteria : radioprotection, planning, cost, environment, circular economy, constraints for the reused project

➔ We conserve Solution 3 regarding the EQER conclusions.



## Circular economy considerations

**Conducted analyses and the Quantitative Radiological Exposure Assessment (“EQER”) allow for an optimal management plan.**

- ✓ Demonstrated the possibility to leave all contaminated soils on site with respect to applicable law
- ✓ Enables the future use of the site as envisaged (shopping centre / leisure park)
- ✓ Enables the application of optimal remediation solution to minimize the environmental risks
- ✓ Prevents CO2 emissions from transport, treatment, storage of contaminated soils
- ✓ Prevents overloading Very low-level waste (VLLW) facilities
- ✓ Saves time, money, and resources



**And radioactive aspect managed without stopping the global remediation work on the site !**





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