

# Overview of options for disposal of radioactive waste

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# Disposal Terminology

## ***Disposal***

- Emplacement of waste in an appropriate facility **without the intention of retrieval**

## ***Disposal Facility***

- An engineered facility where waste is emplaced for disposal (synonymous with repository).

## ***Near Surface Disposal Facility***

- Located on the Earth's surface.
- Or within a few tens of metres below the ground level

## ***Geological Disposal Facility***

- A facility for radioactive waste disposal located underground (usually several 100 m or more below the surface)
- A stable geological formation is needed to provide long term isolation of radionuclides from the biosphere

(IAEA Safety Glossary 2018 Edition)

## The Specific Aims of Disposal of Radioactive Waste

- To contain the waste
- To isolate the waste from the accessible biosphere
- To reduce likelihood of inadvertent human intrusion into the waste



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## Current status of disposal of Radioactive Waste

- Several designs for disposal facilities have been developed
- These **design have different degrees of containment** and isolation capability
  - The facilities were designed for the type of radioactive waste that they will receive.
- Various types of disposal facility have been constructed in many States and are in operation.



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# The Waste Classification Scheme

IAEA Safety Standards

for protecting people and the environment

Classification of  
Radioactive Waste

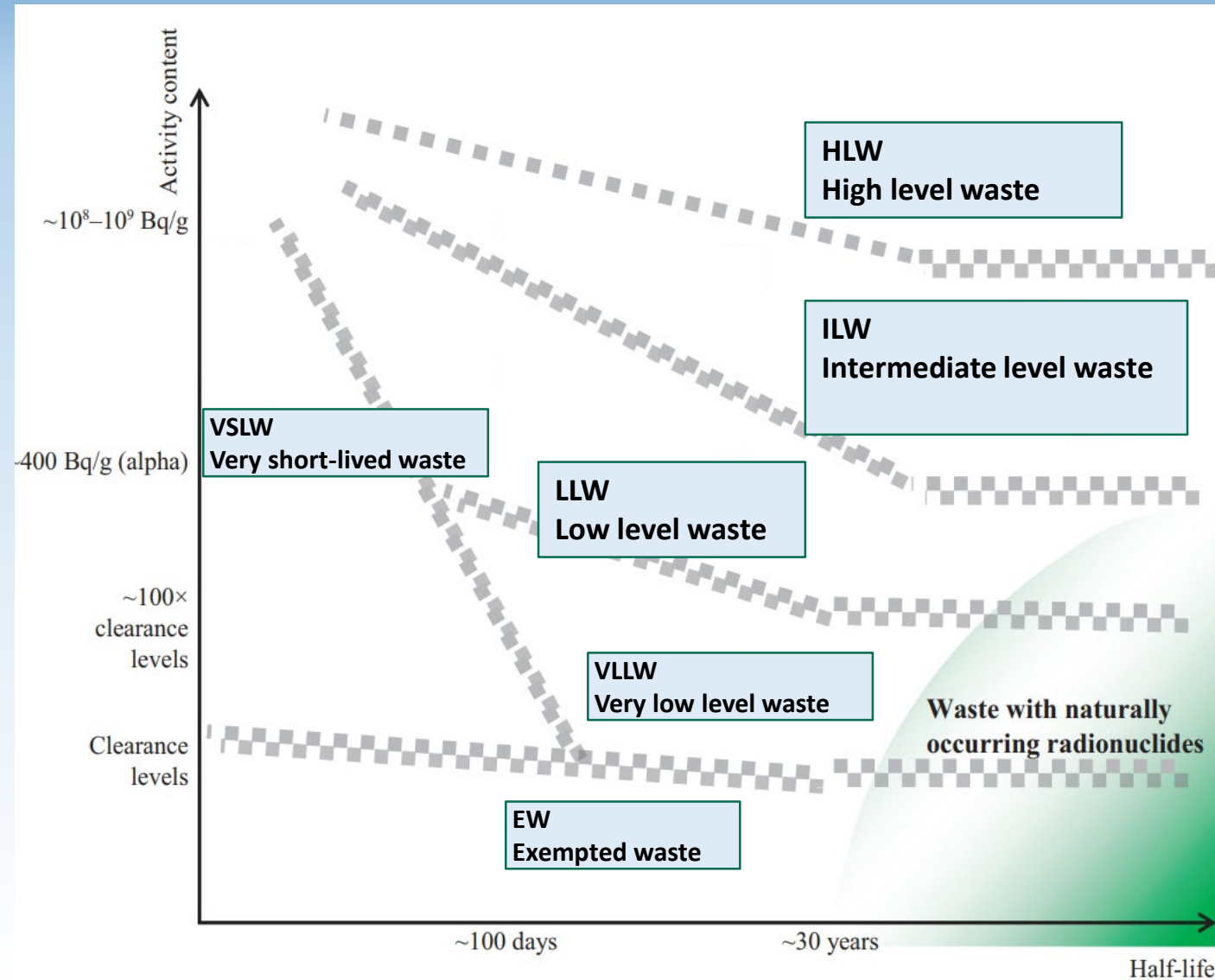
General Safety Guide

No. GSG-1

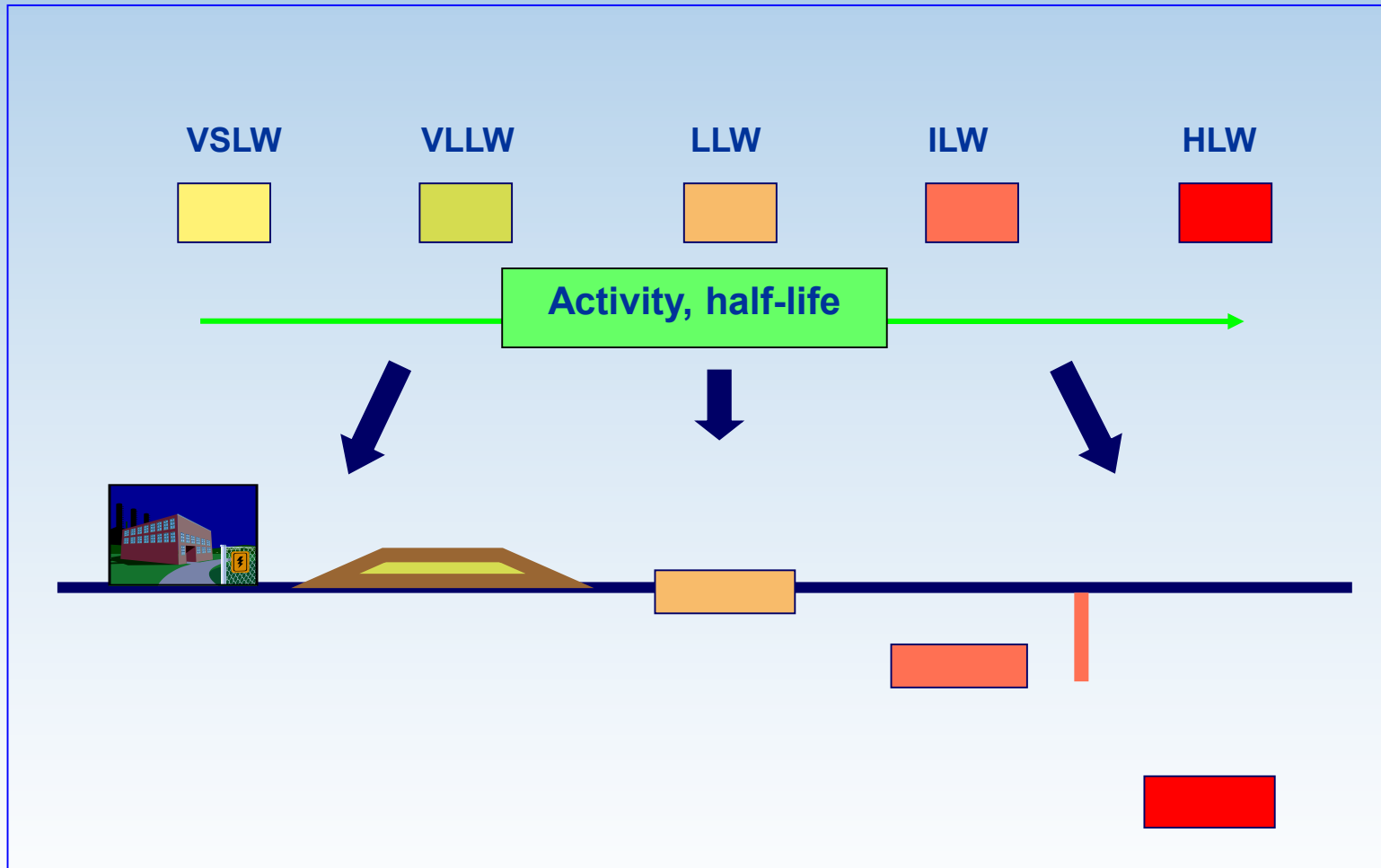


IAEA

International Atomic Energy Agency



# Waste Classes & Relevant Disposal Options



# Disposal Options for RAW

## Near surface

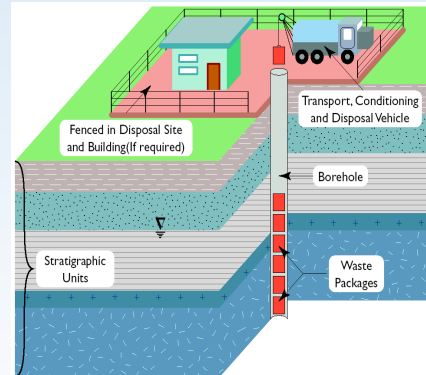
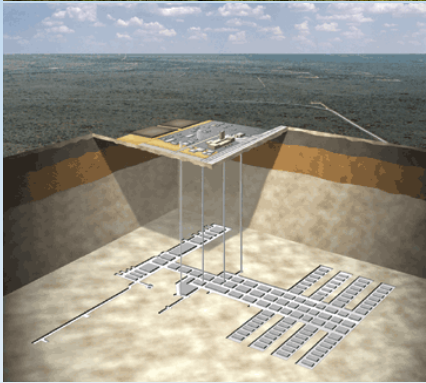
- For short-lived RAW, low-activity sources
- Available in many countries

## Geological

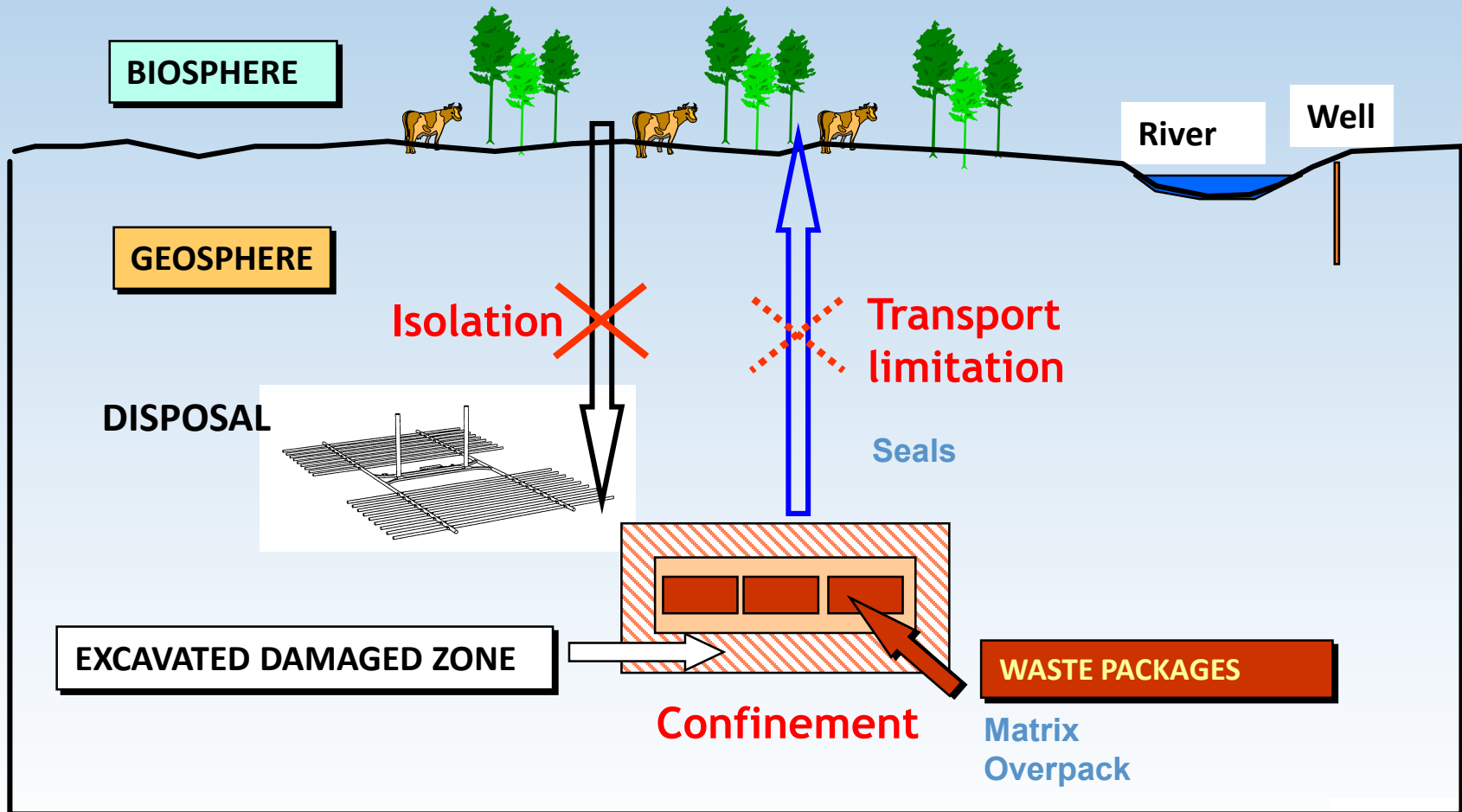
- For all types of RAW and sources
- Not yet available in most countries

## Borehole

- For all types of Disused Radioactive Sources
- A possible safe and secure solution without waiting decades for geological disposal
- Very relevant for countries with DSRS that will not have geological disposal
- Not yet available



# IAEA Specific Safety Guide 14 (SSG-14) Geological Disposal Facilities for Radioactive Waste





# Disposal Terminology

## ***Containment***

- Methods or physical structures to prevent or control the release and the dispersion of radioactive substances

## ***Confinement***

- Prevention or control of releases of radioactive material to the environment in operation or in accidents

## ***Isolation*** of radioactive waste in a disposal facility

- Physical separation and retention of radioactive waste from people and the environment
  - **Short-lived waste:** **Several hundreds of years**
  - **Intermediate level waste and high-level waste:** **At least several thousand years**
  - Isolation is an inherent feature of geological disposal.

(IAEA Safety Glossary 2018 Edition)



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# The disposal system

## The near field

- Types of waste
  - Origin, nature, quantities and properties of waste
  - Radionuclide inventory
- System engineering
  - Waste conditioning and packaging, disposal units
  - Engineered barriers, cover of the disposal facility, drainage features
- Extent and properties of the zone disturbed by any excavation or construction work

## The far field (the way from the facility to the biosphere)

- Geology, hydrogeology, hydrology, geochemistry
- tectonic and seismic conditions, erosion rates

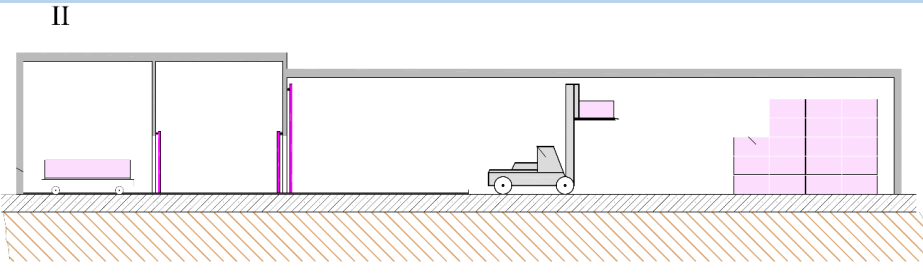
## The biosphere

- Location of the disposal facility
- Climate and atmosphere, water bodies
- Biota, soils, topography and the geographical extent and
- The local population and human activities (Para 4.37 SSG-23)

# Examples for planned or existing disposal facilities

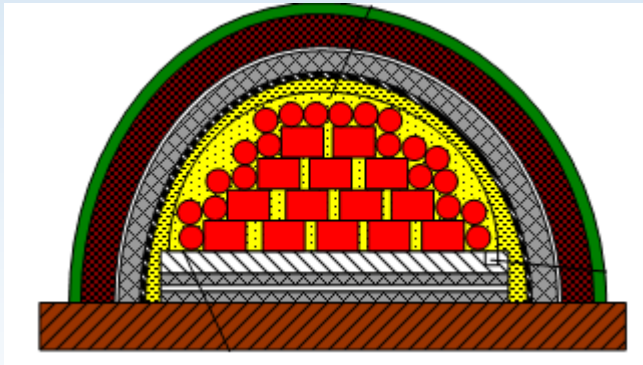
# Near Surface Disposal: A landfill for VLLW (LEI, Lithuania)

## Buffer storage facility



- Located in the Ignalina NPP (Lithuania) industrial site;
- In operation.

## Disposal modules



- Located in the Ignalina NPP sanitary protection zone (R=3 km);
- Under construction.

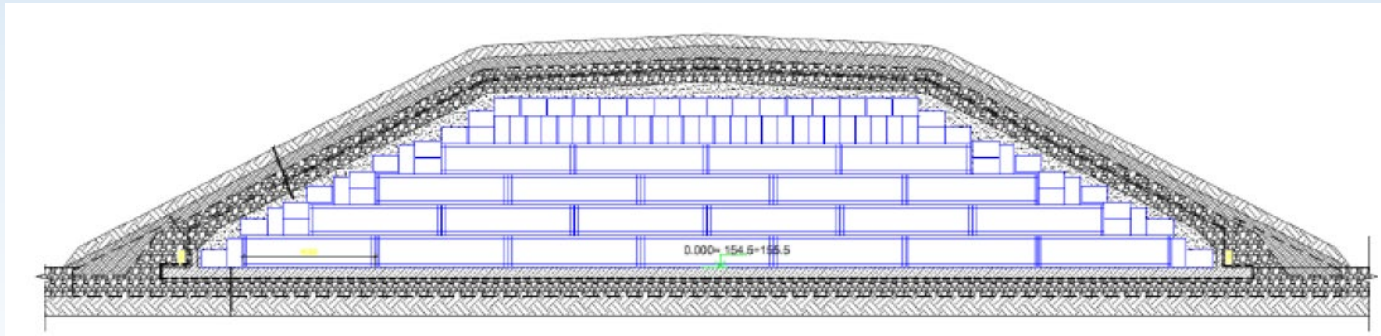
# Near Surface Disposal: A landfill for Very Low Level Waste (LEI, Lithuania)(cont.)

## Waste packages:

– Compacted waste in bales



– FIBC;

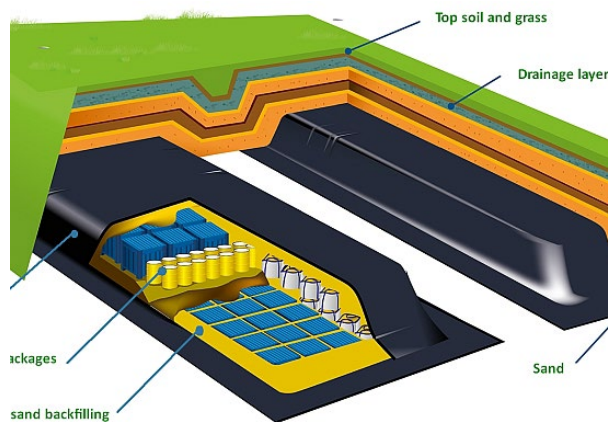
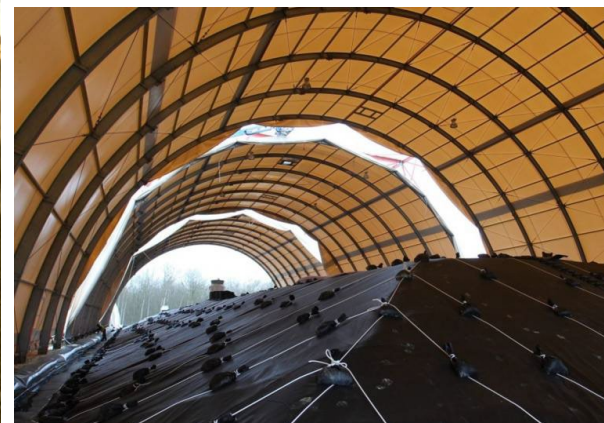
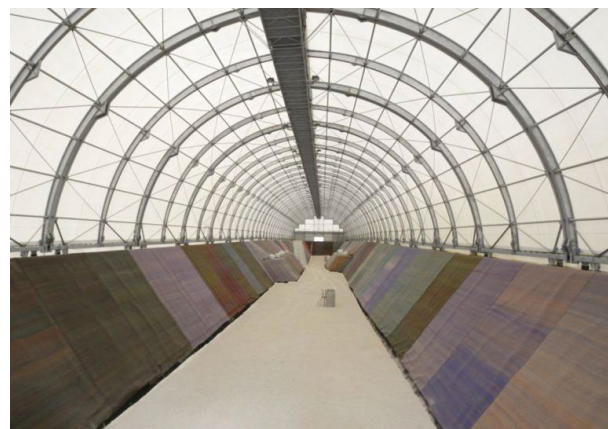


**FIBC** (=Flexible Intermediate Bulk Container





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## Near Surface Disposal in France A facility for very low-level waste (VLLW)



# Facility for Very Low Level Waste in France

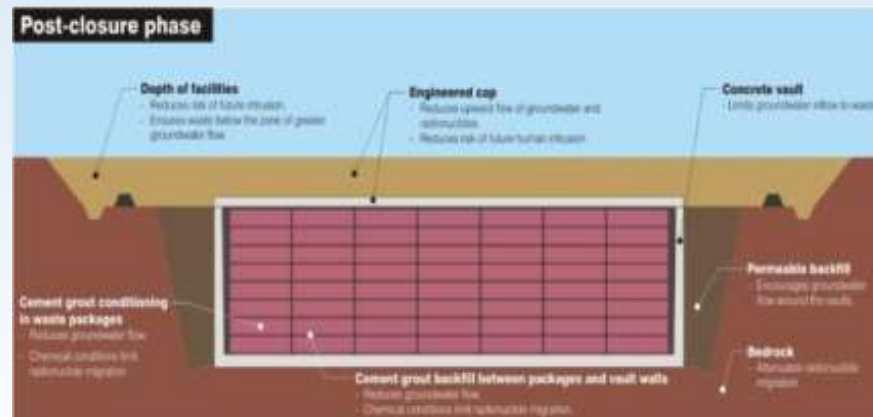
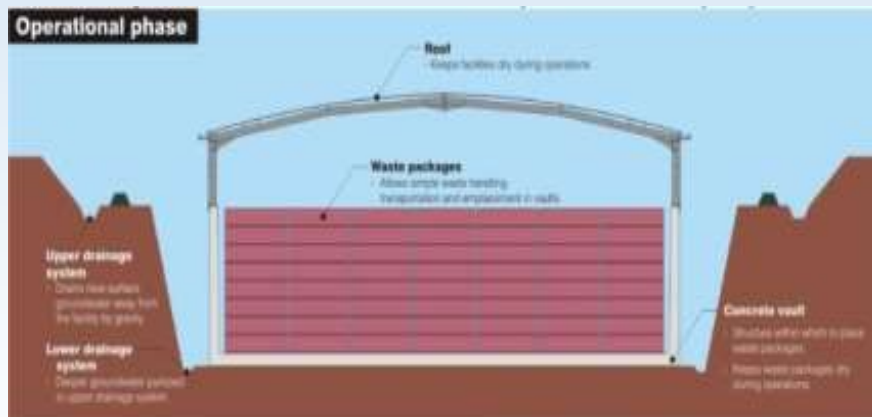
- **Operation since 2003 in Aube (France)**
  - Very Low Level Waste is disposed of in a dedicated facility, the **first of its kind in the world**.
- **Specifications**
  - About 30,000 m<sup>3</sup> are disposed per year
  - Trenches 176 m x 25 m dug several metres deep in a clay layer.
  - After filling, the trenches are covered by a capping system composed of natural materials and a geomembrane, ensuring water tightness.
- **Operation**
  - All operations are conducted under the a mobile shelter.
  - The mobile shelters can be moved from one trench to the next on a rail-sliding system.
  - Disposal cells are excavated directly in the clay layer down to a depth of 8 m
  - Operation one-by-one disposal cell.



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# Near Surface Disposal

Disposal in the vaults between 0 and 30 m underground above the water table





# Near Surface Disposal



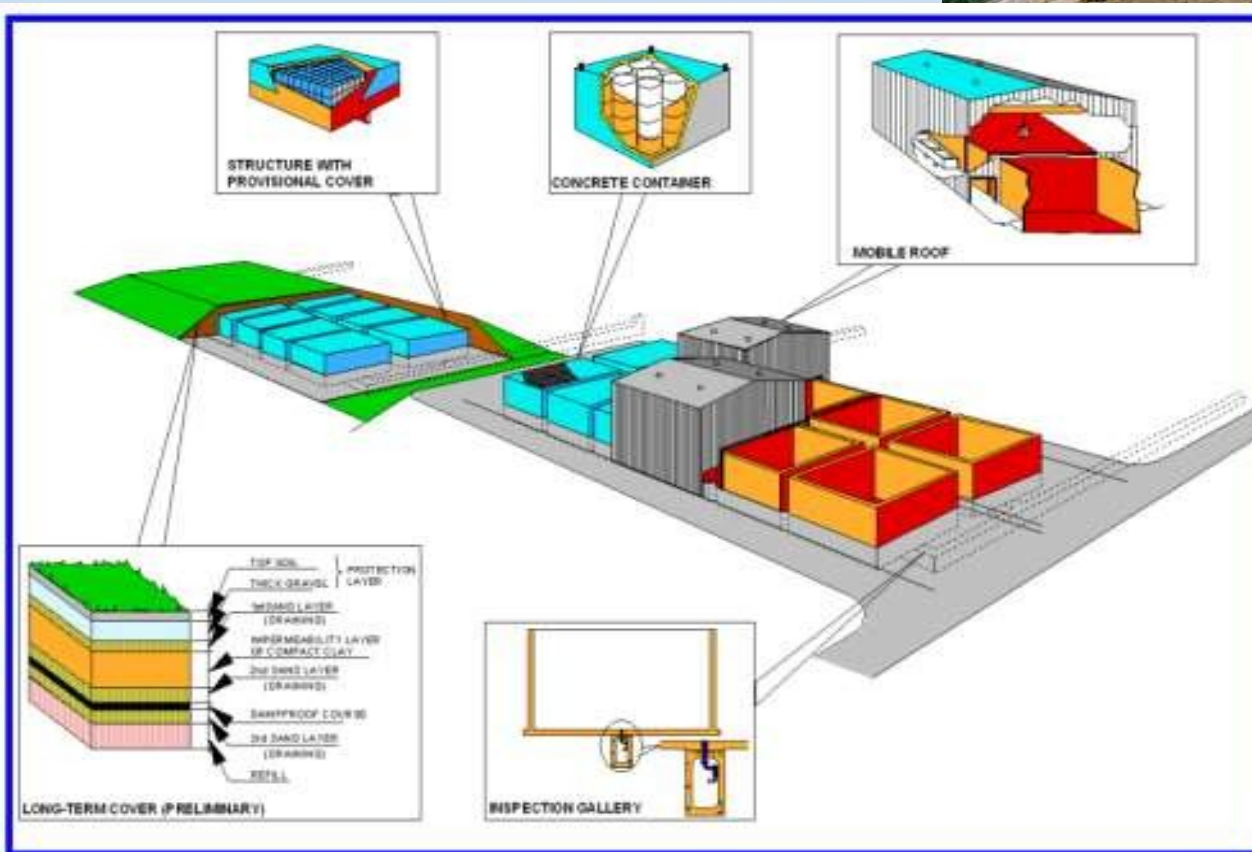


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# Near Surface Disposal Facility in El Cabril, Spain

## Waste types

- Very low-level waste
- Low level waste
- Intermediate level waste



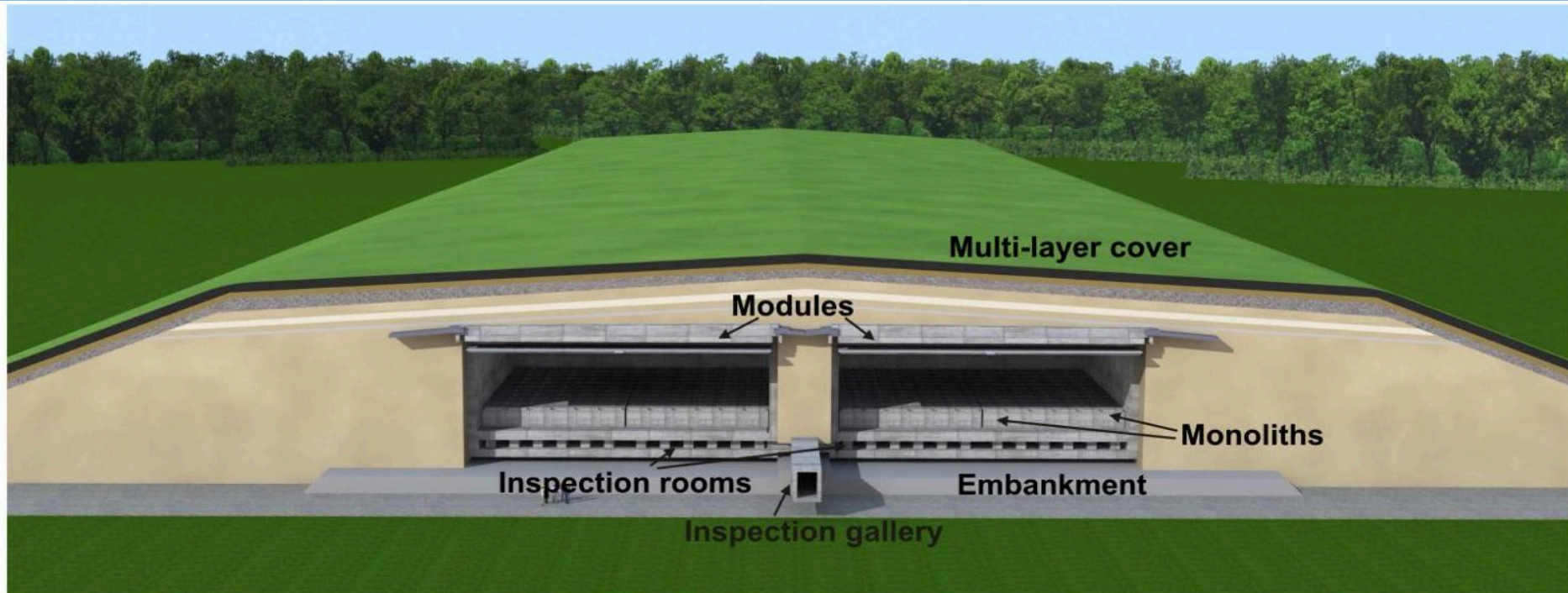
Disposal in the vaults above ground level





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# A planned near surface disposal for Cat A waste (Belgium)



## Cat A waste

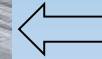
- Short lived waste with low and intermediate level specific activity
- $\sim 50.000 \text{ m}^3$  (75% of total volume)
- 0,5% of the total activity of all waste

# A near surface disposal for Cat A waste (Belgium) (cont.)



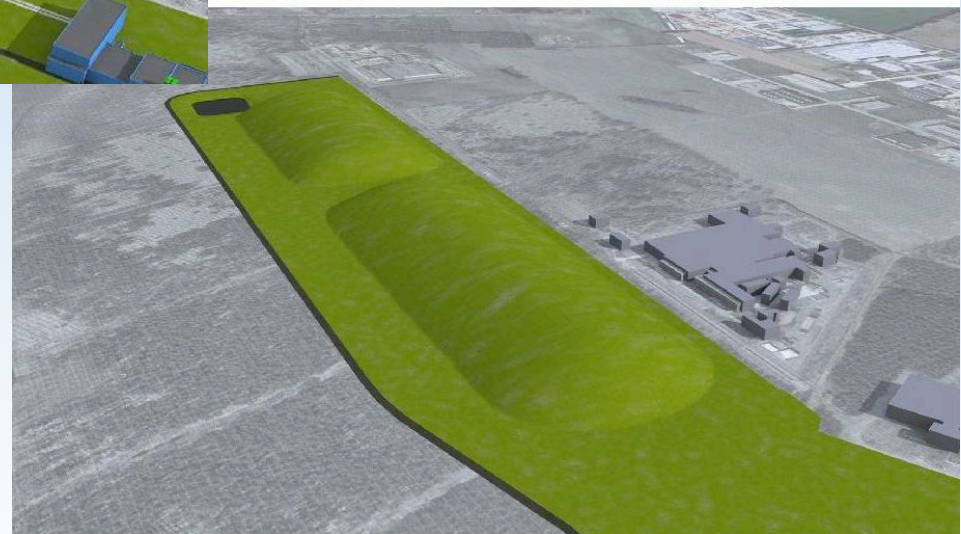
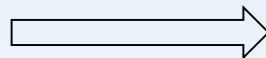
Operating phase:

34 modules (20+14)



Post-closure phase

after placement of the  
multi-layer cover

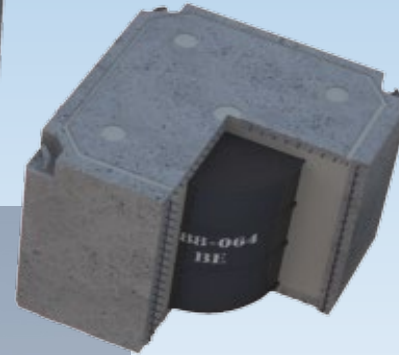
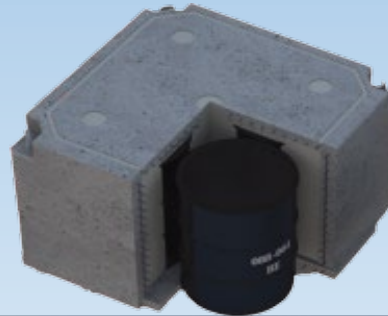




# Near surface disposal for Cat A waste (Belgium) (cont.)

## 3 types of monoliths

- Standardised waste drums
- Non-standard (historical) waste drums
- Bulk waste (larger pieces decommissioning)



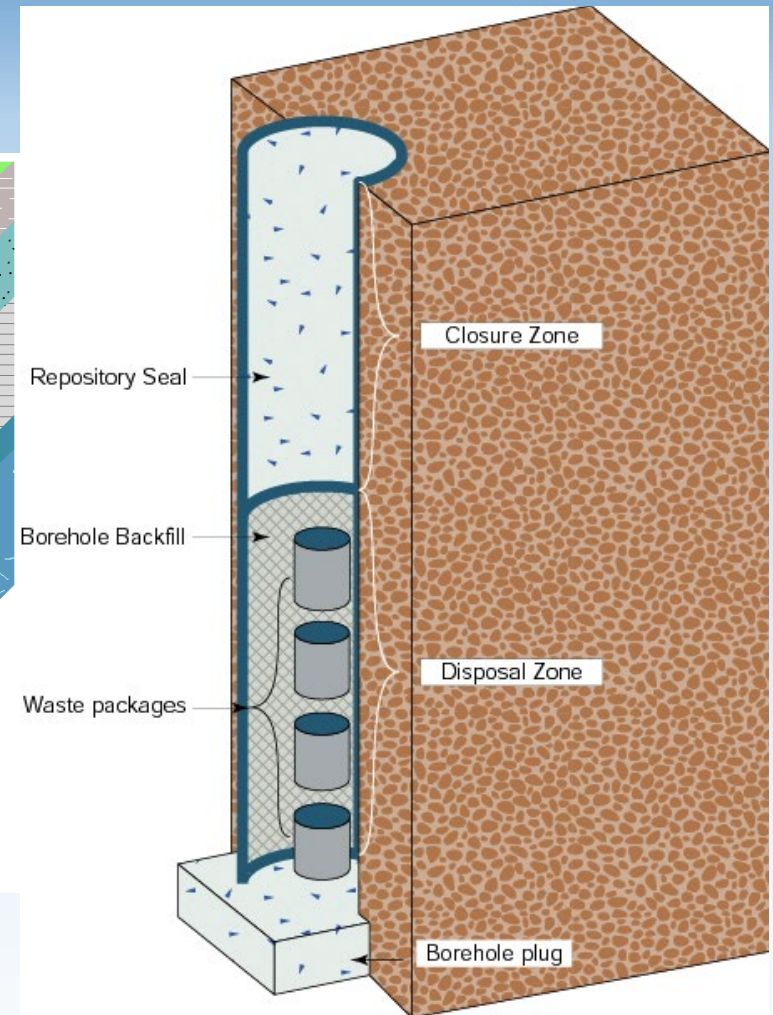
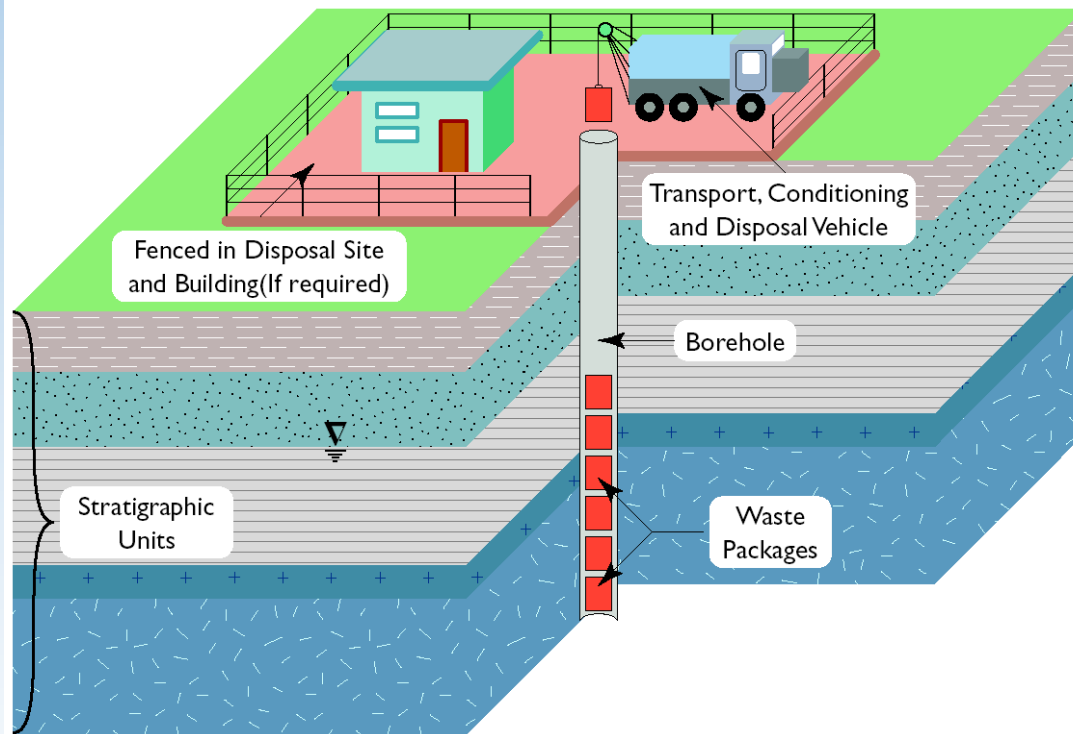
## Disposal facility

- Vault type
- Fixed steel roof attached to modules
- Inspection room
- Inspection gallery



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# Borehole Disposal for used radioactive sources



# Borehole Disposal for disused radioactive sources

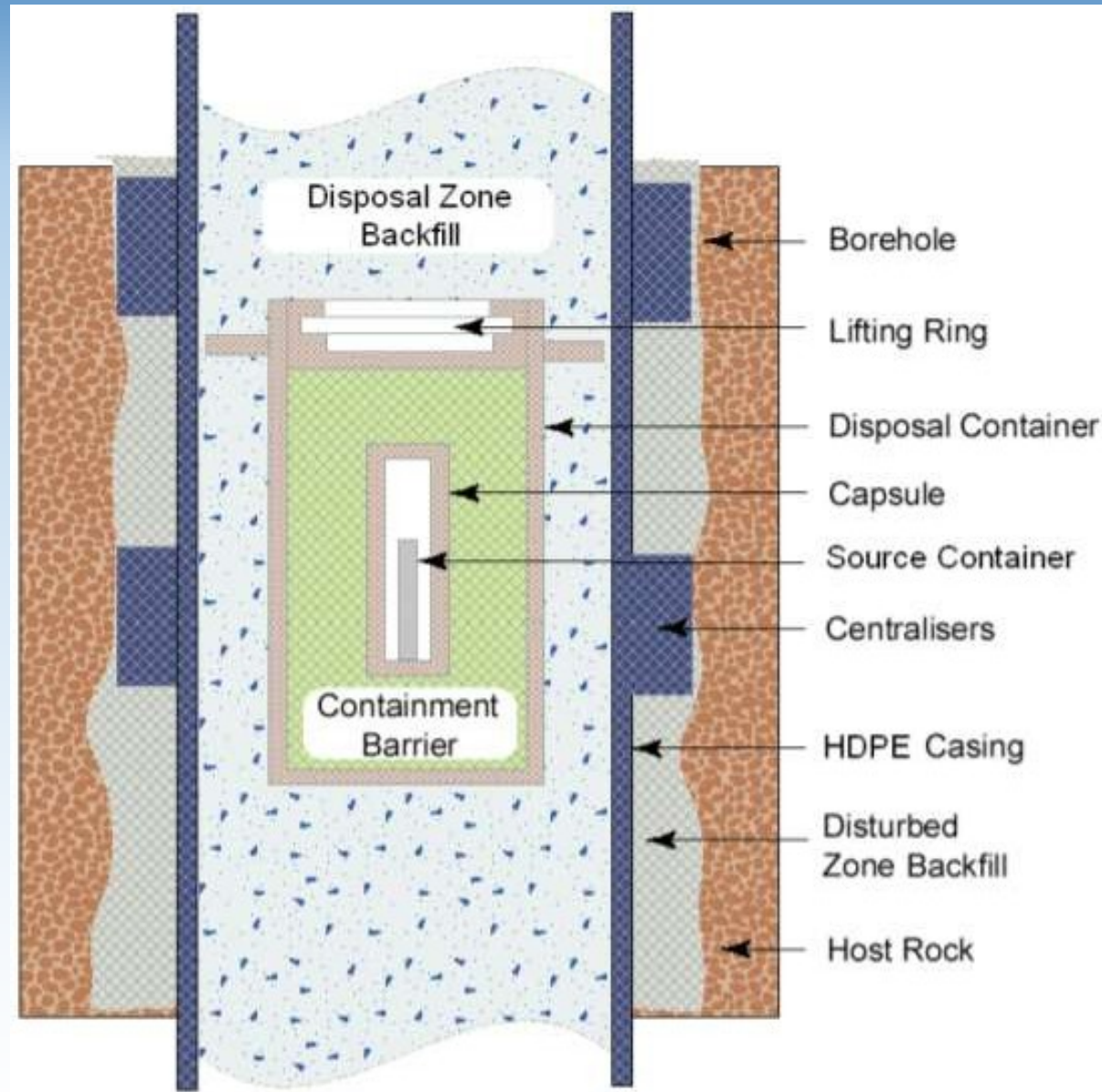


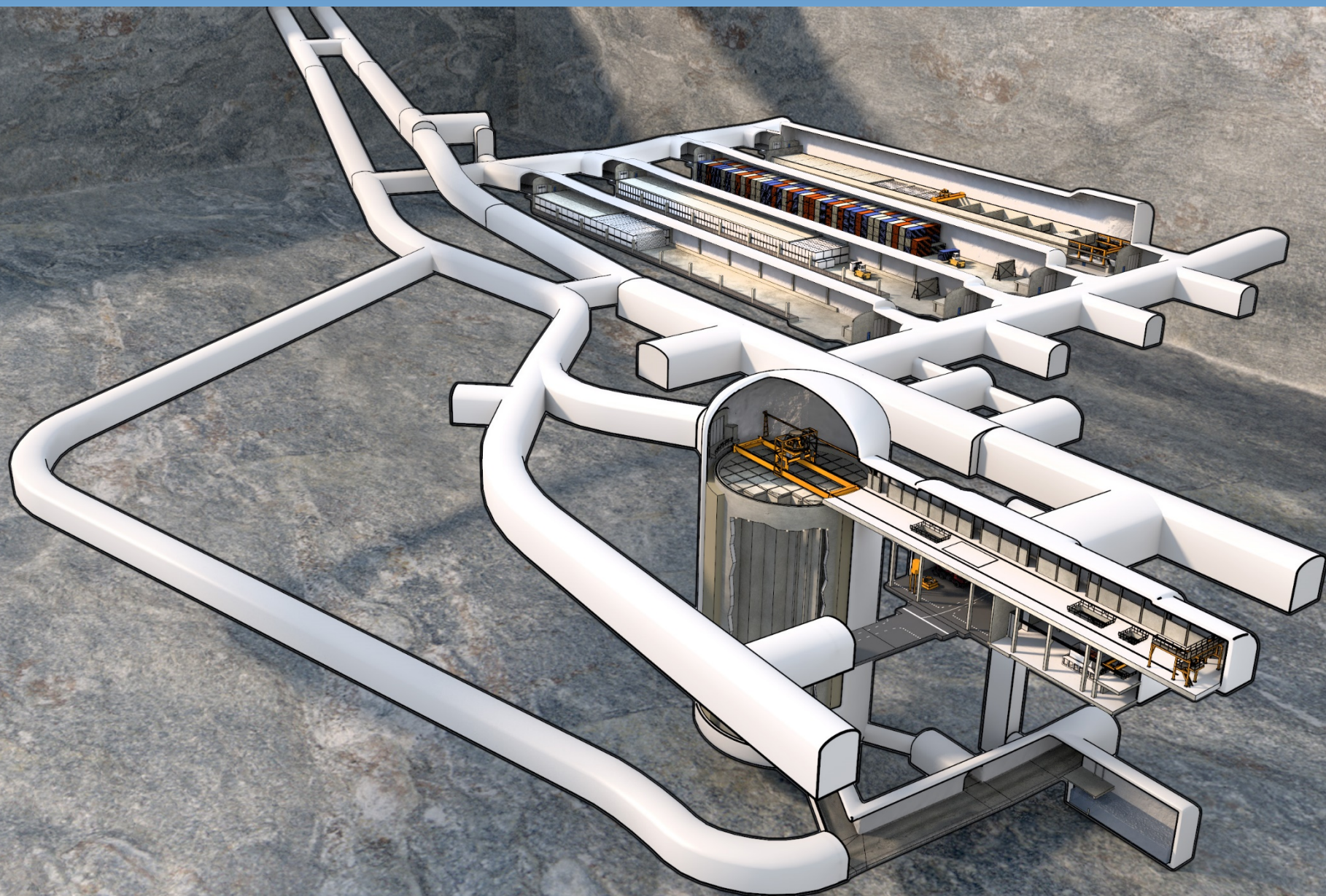
FIG. 109. A schematic illustration of possible components of a borehole disposal system.





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# Intermediate Depth Disposal for Intermediate Level Waste





# Geological Disposal for high level waste



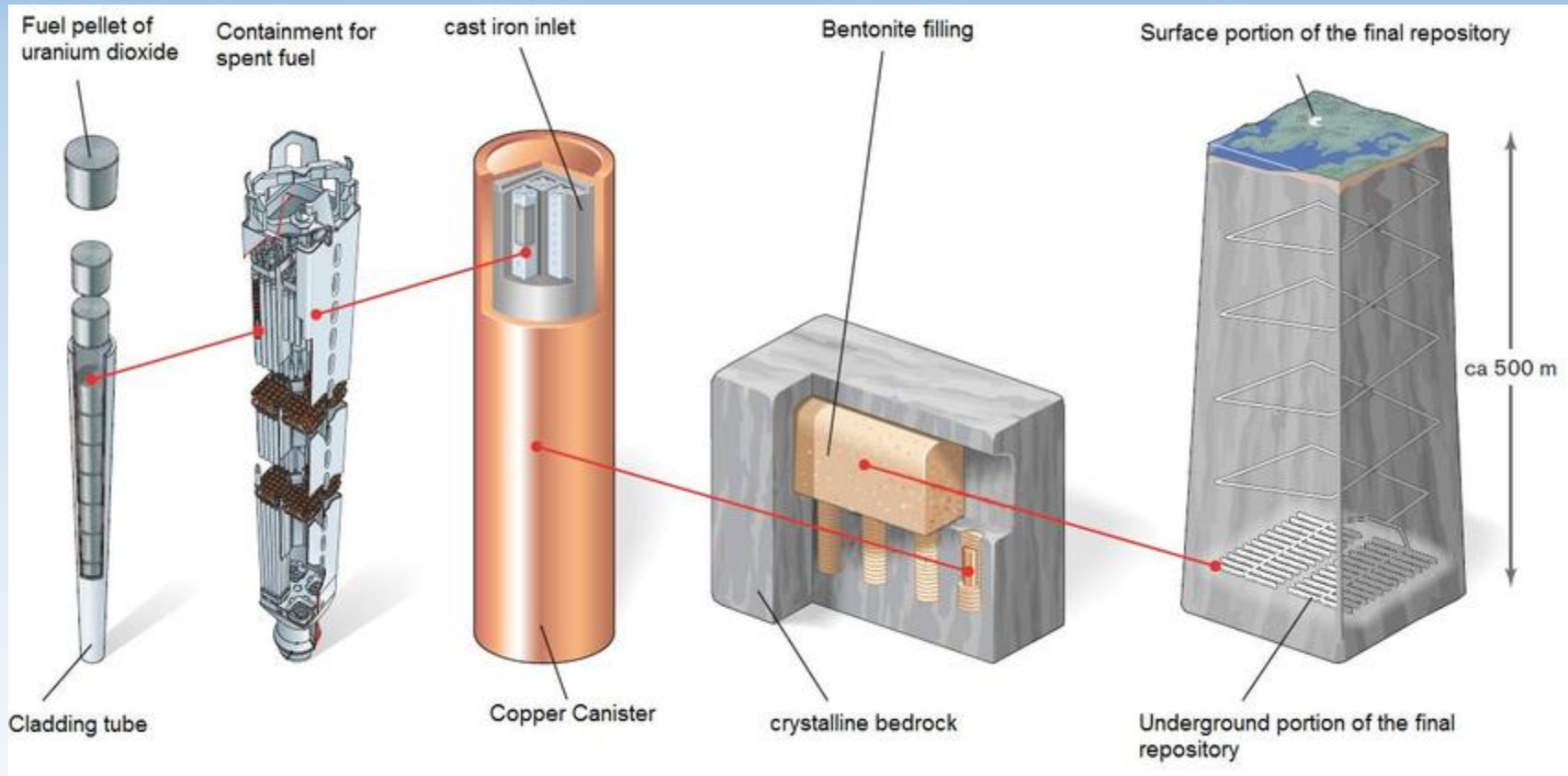
## ***Sweden:***

Fuel placed in isolating copper canisters with a high-strength cast iron inserts



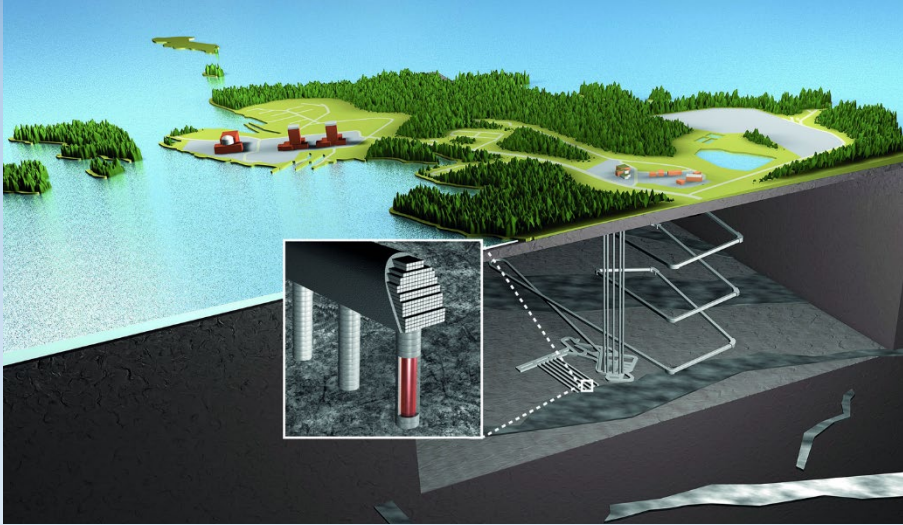
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# Multi-barrier system in for high level waste



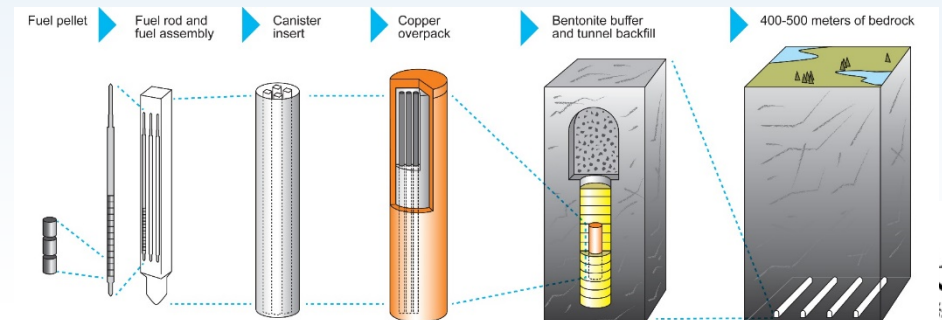
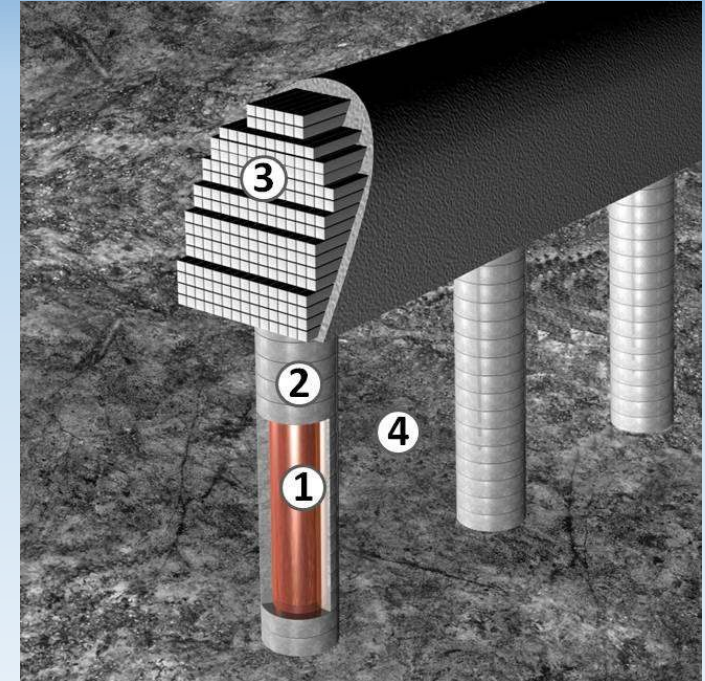
Canisters are surrounded by bentonite clay in individual deposit holes at 500 m depth in granitic bedrock

# Geological disposal for high level waste in Finland



## Developing the First Ever Facility for the Safe Disposal of Spent Fuel

<https://www.iaea.org/newscenter/news/developing-the-first-ever-facility-for-the-safe-disposal-of-spent-fuel>



The Onkalo disposal facility



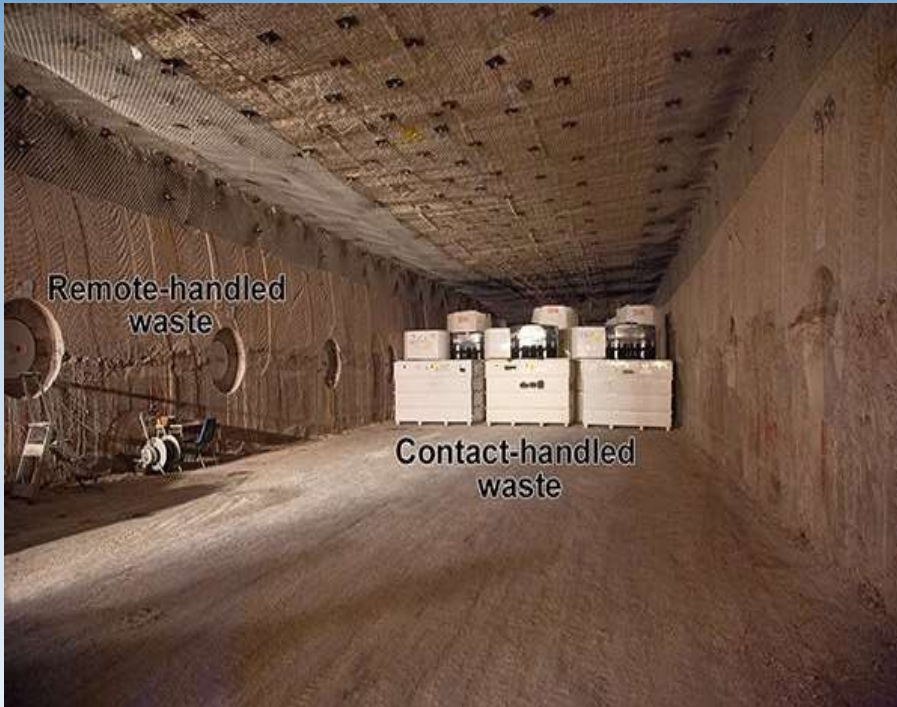


# Geological Disposal

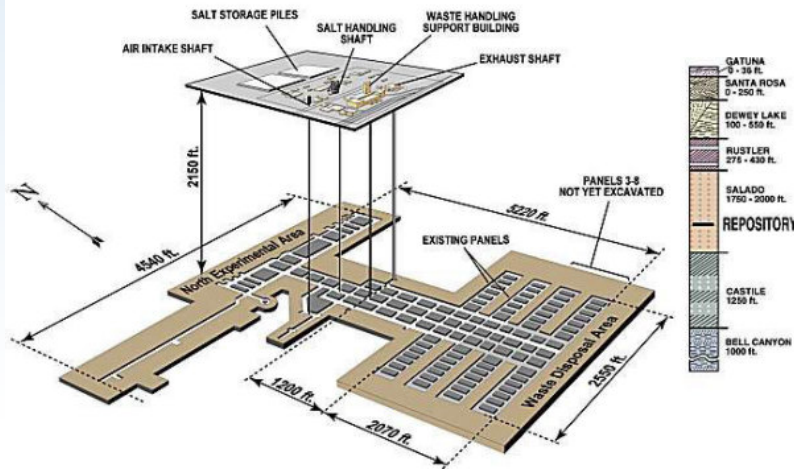
- The Onkalo disposal facility for spent fuel being constructed in Olkiluoto, Finland
- It consists of an engineered system of tunnels.
- Onkalo is also used to characterize the host rock to support safety case development.

*(Photo: Posiva Oy)*

# Geological Disposal in USA



WIPP Facility and Stratigraphic Sequence



- The **W**aste **I**solation **P**ilot **P**lant (WIPP) is authorised to store transuranic radioactive waste for 10,000 years.
- The waste is from the research and production of United States nuclear weapons.





## Geological Disposal of low and intermediate level waste

- The **Konrad Disposal Facility** is a former iron ore mine near Braunschweig (Germany)
- Scheduled to start in 2022
- Maximum capacity 303.000 m<sup>3</sup>

# Summary

- **Learning from other Member States' experiences and design solutions**
  - There are many ways of providing long-term safety
  - There is no single best disposal solution for near-surface or geological disposal
- **Factors to be considered for designing an optimal solution**
  - Disposal inventory
  - characteristics of the site and available resources to develop
- **Natural and technical barriers**
  - Explore and evaluate the barriers
  - Use of this understanding in the safety assessment and the safety case
- ***Continuous iterative process between design and safety assessment of disposal facility, considering it as a system***

***Thank you!***