



ONDRAF/NIRAS

The safety concept for the Dessel surface repository

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Overview

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The disposal
concept

2
Safety
objective,
principles and
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safety concept

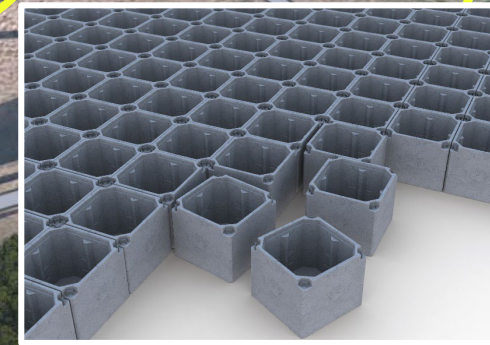
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Long-term
safety concept

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Defence in
depth



The disposal concept

The site at a glance



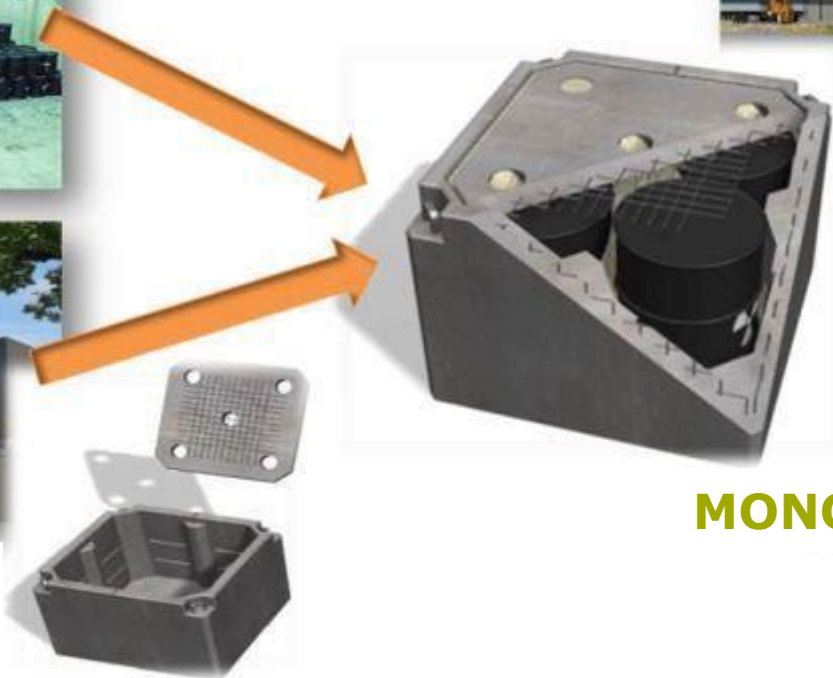
Disposal packages (monoliths)

Storage (Belgoprocess)

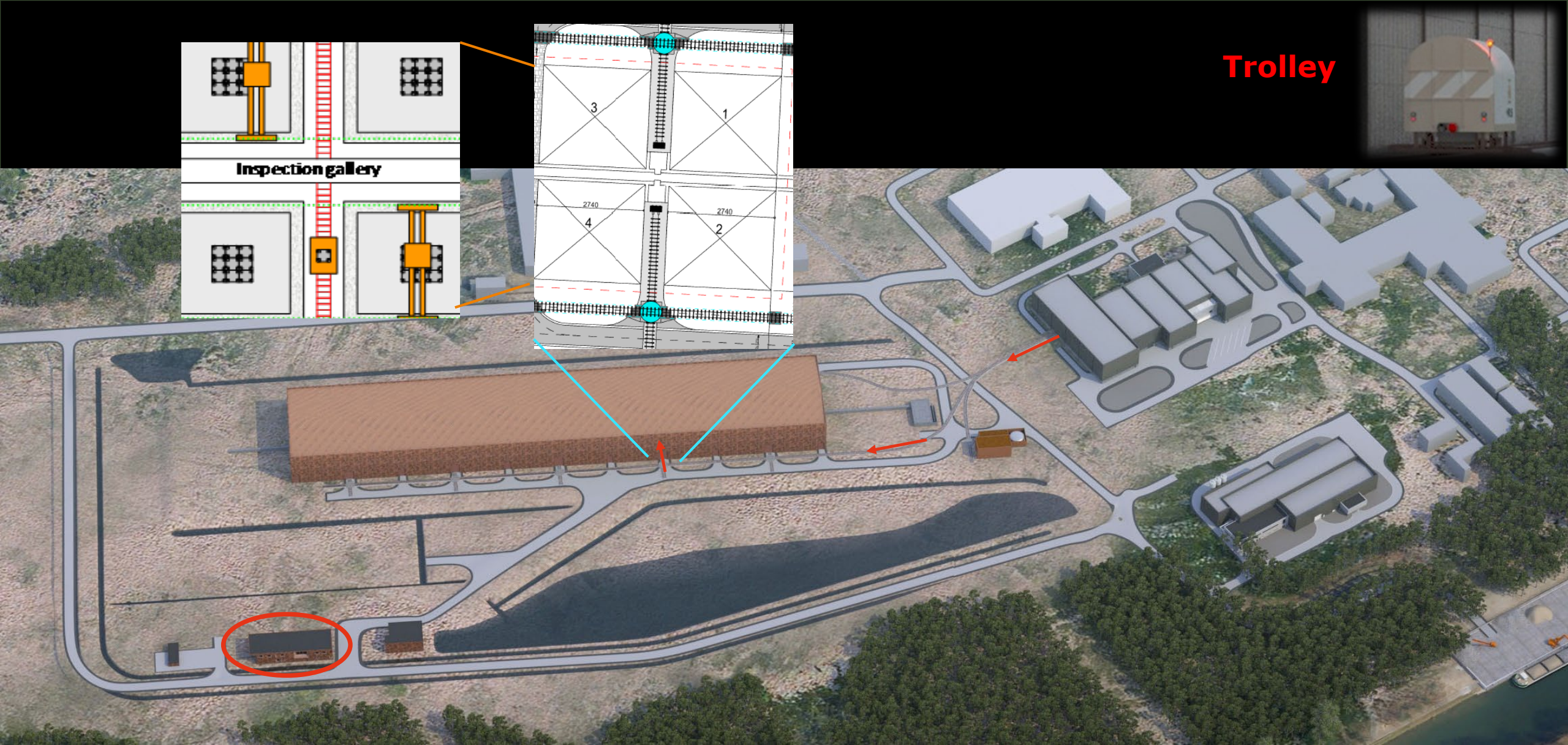


Caisson factory

Installation for the production of monoliths (IPM)



MONOLITH



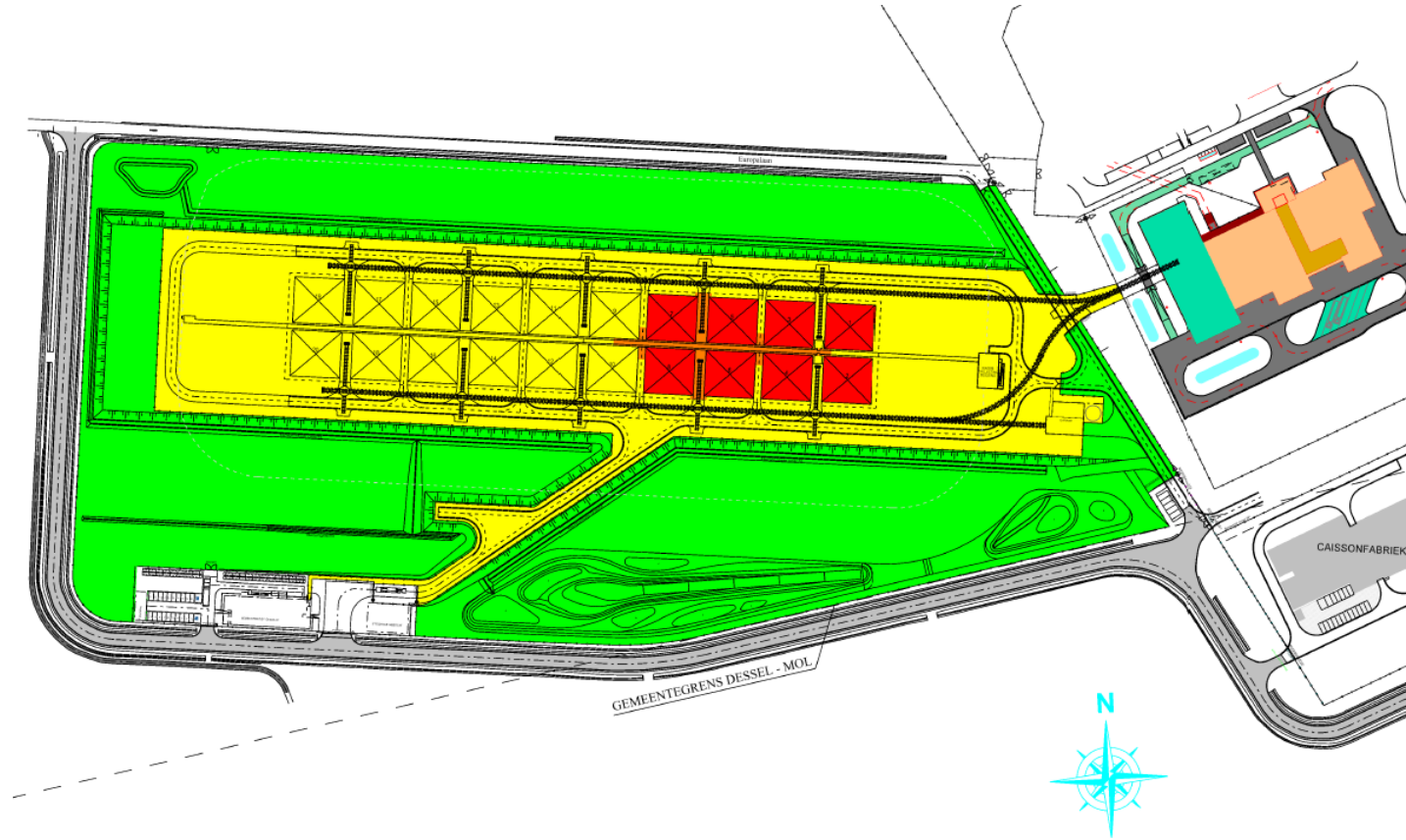
Trolley

Control room (entrance cluster)

Operations are remote-controlled and semi-automatic

Full capacity:
~ 1000 monoliths per year

Zoning during waste emplacement



Layout of a module

Module roof

structural top slab

shielding slabs

gravel-filled inter-monolith space

monoliths

module wall

Module base

support slab

columns

inspection room

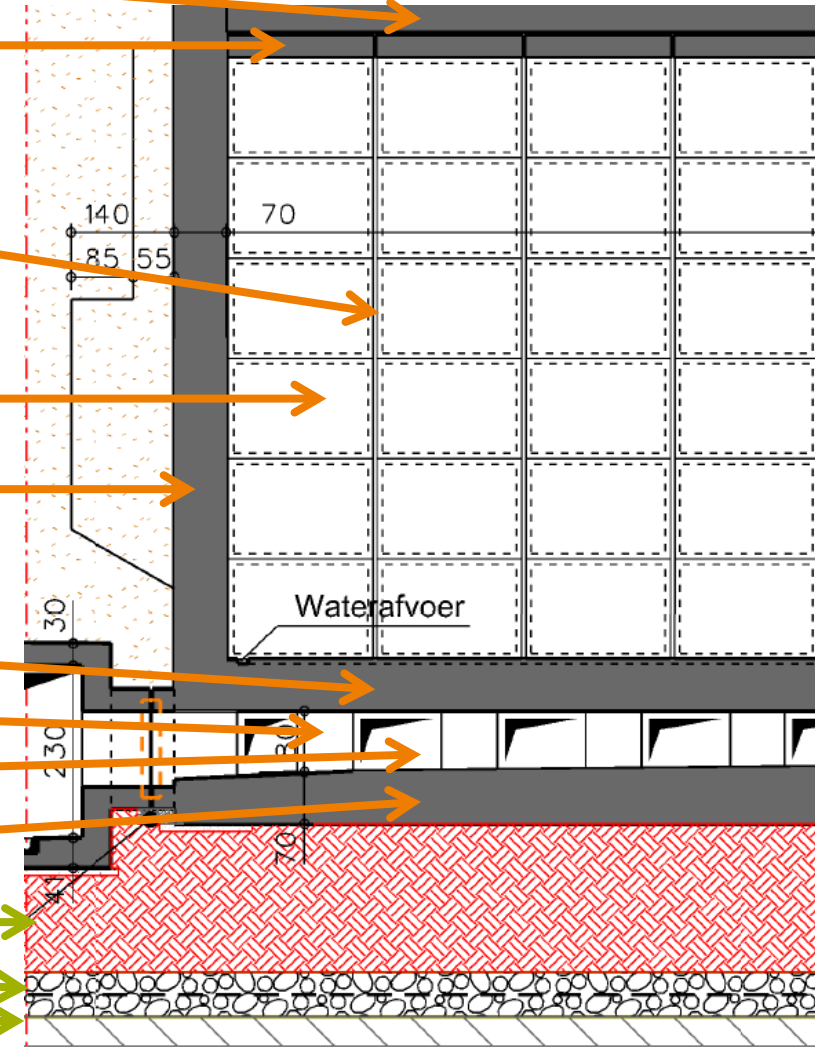
foundation slab

Foundations

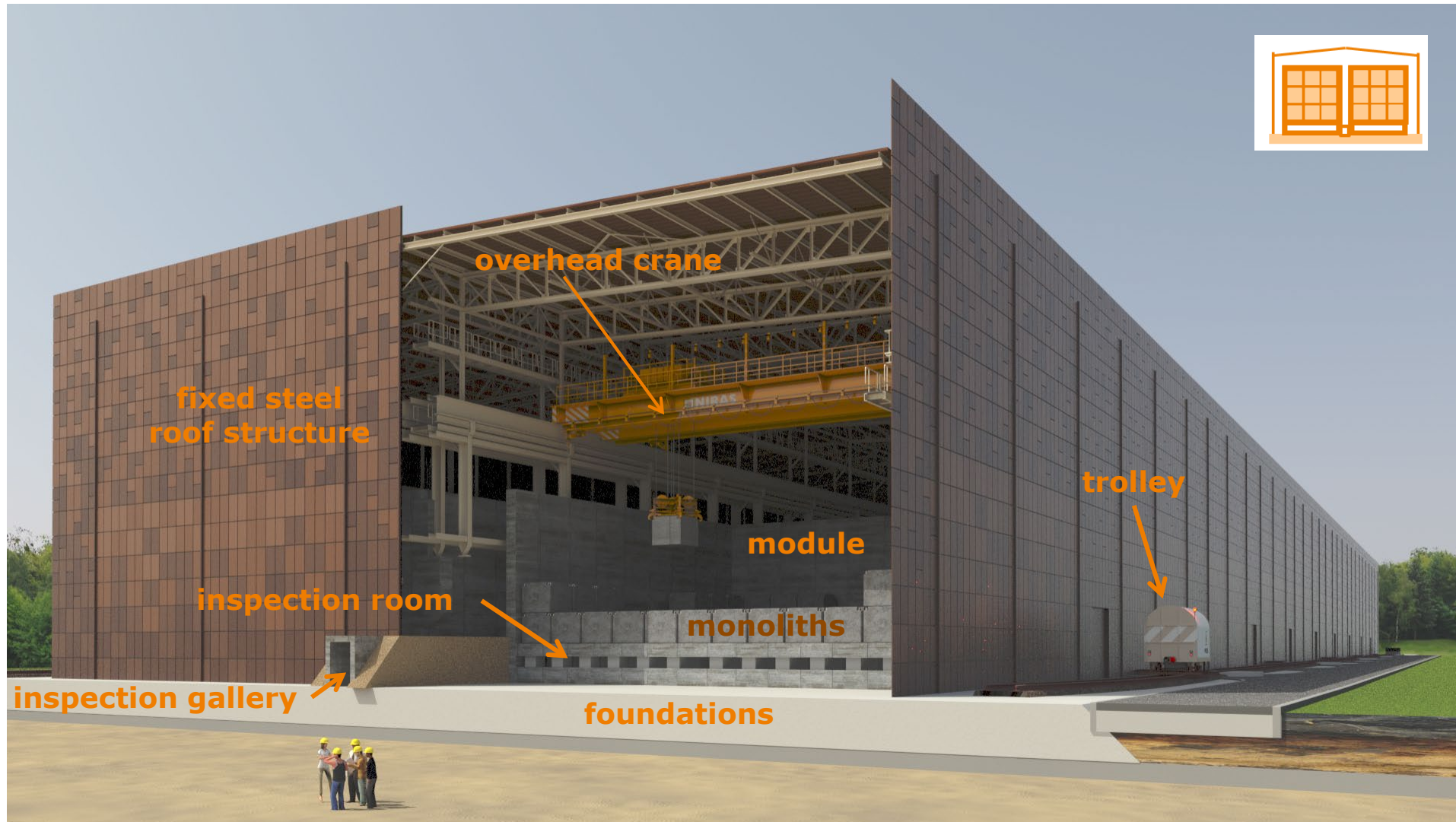
sand-cement embankment

gravel layer

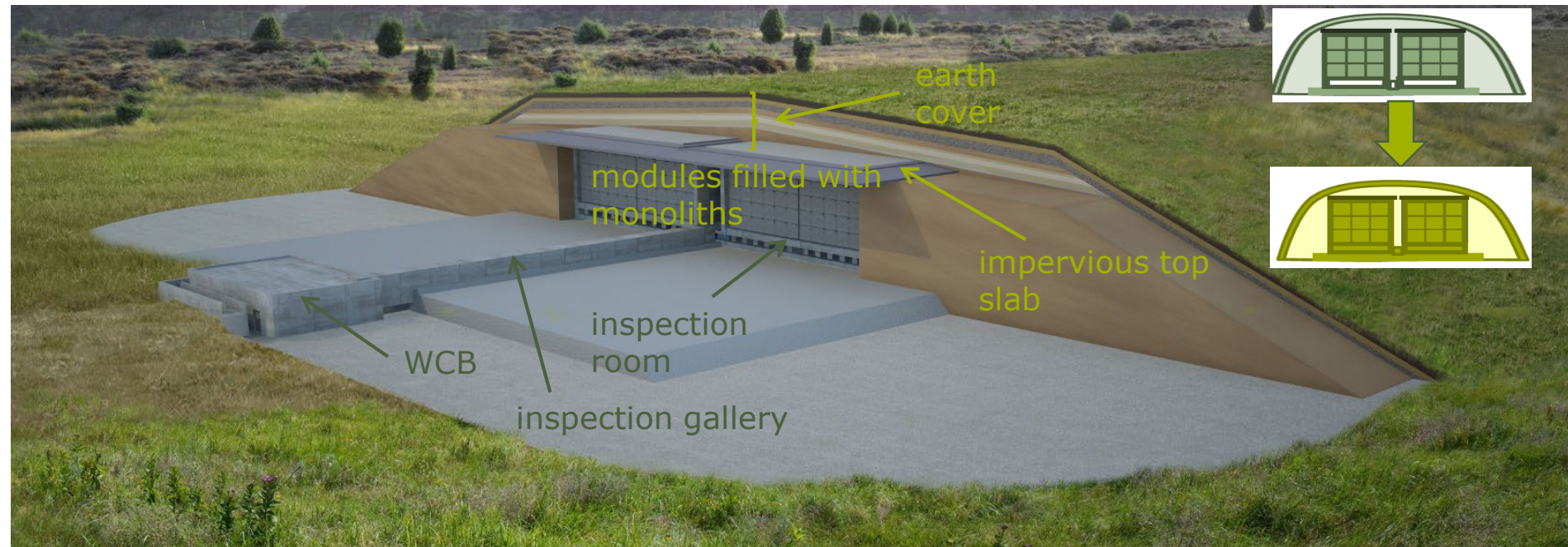
soil improvement



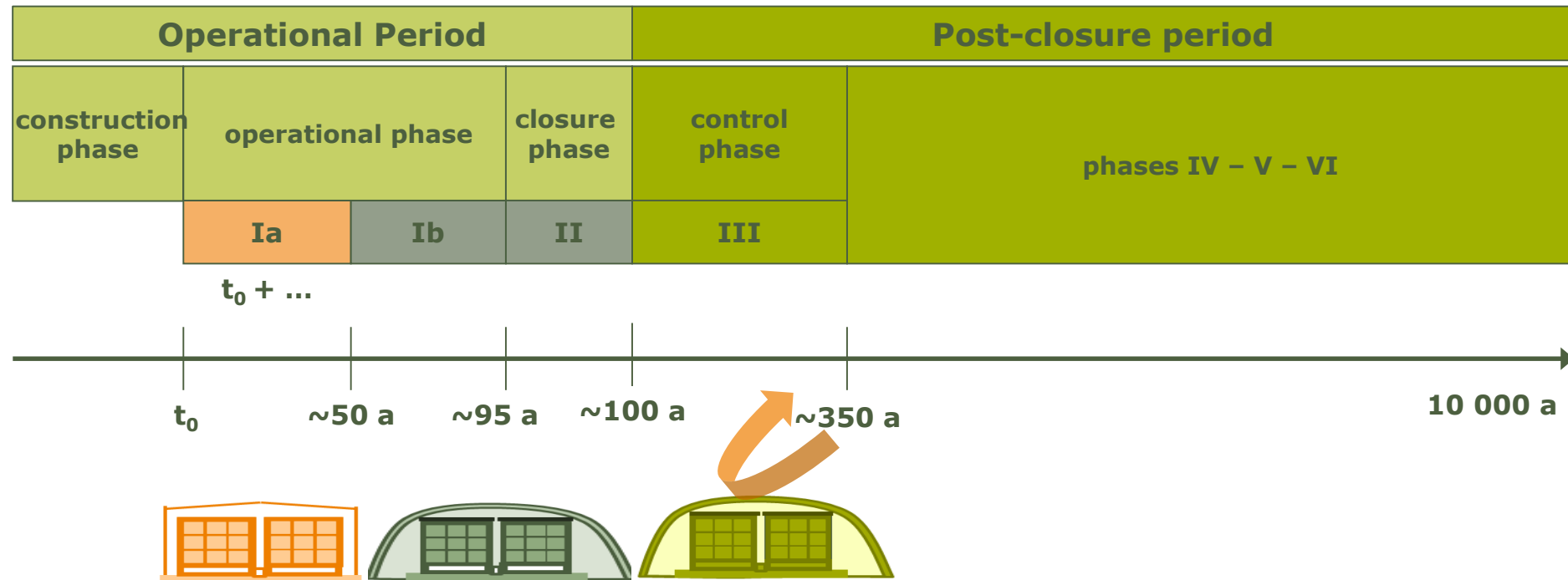
Disposal modules in operation



Filled modules



Timeframes





Safety objective, principles and safety functions

Safety objective and principles

Protecting humans and the environment

- **now and in the future, without imposing undue burdens on future generations**
 - ✓ operational
 - ✓ long term: passive safety
- **from harmful effects of ionizing radiation**
 - ✓ radiation protection principles
 - ✓ limiting the activity content of long-lived radionuclides
 - ✓ isolate and contain
- **by preventing accidents and, should an accident occur, limiting its consequences**
 - ✓ defence in depth

Safety functions

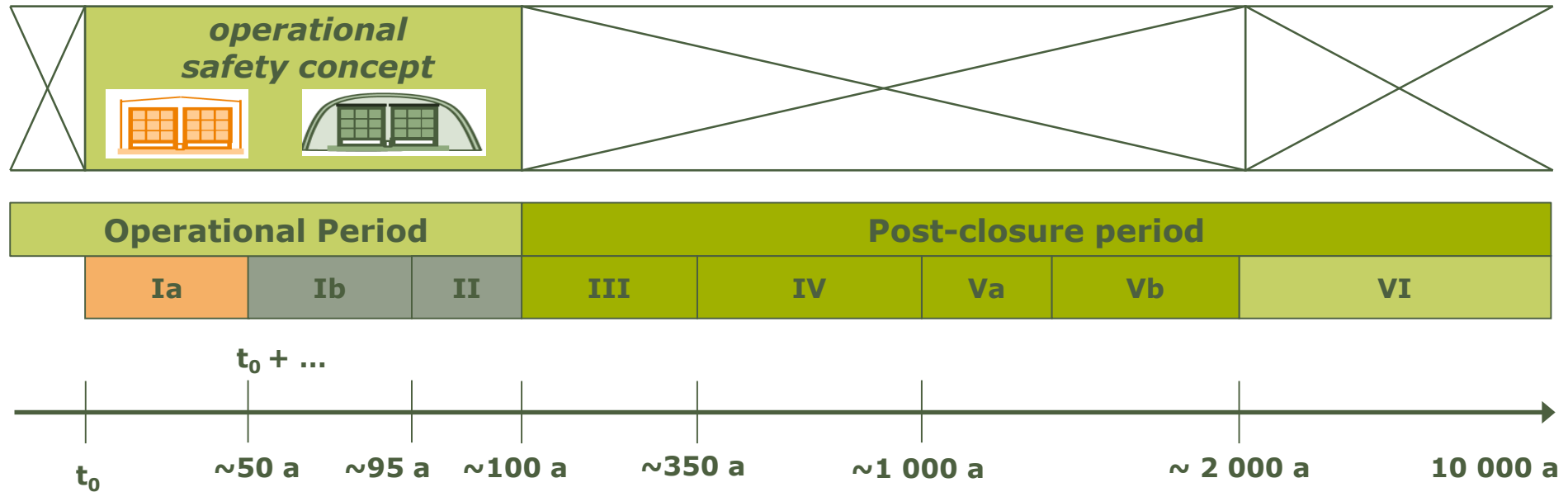
- Safety is ensured by a combination of **systems, structures and components (SSCs)**
- SSC properties allow for safety in both 'normal' conditions and in case of incidents/accidents → **safety functions**

| Operational period | Post-closure period |
|--------------------|---------------------|
| Containment | Containment |
| Isolation | Isolation |
| Shielding | |
| Protection | Protection |



Operational safety concept

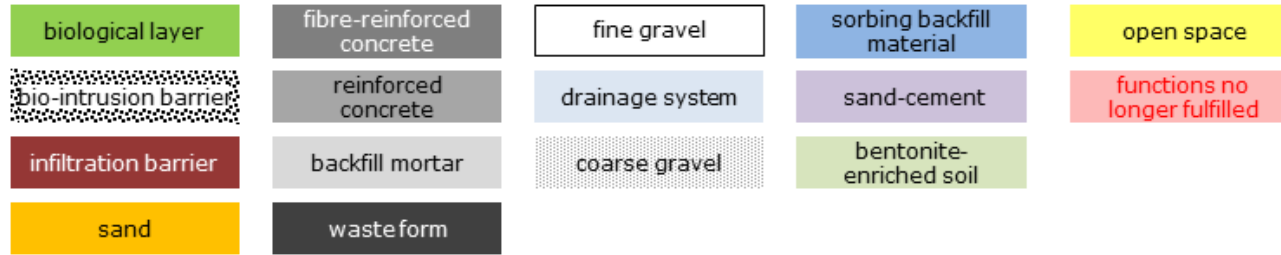
Timeframes



Containment

- Normal operating conditions:
 - ◆ **containment** of radionuclides inside monolith
 - ◆ no contamination
- Other SSCs help ensure containment in case of **accidents**

Containment



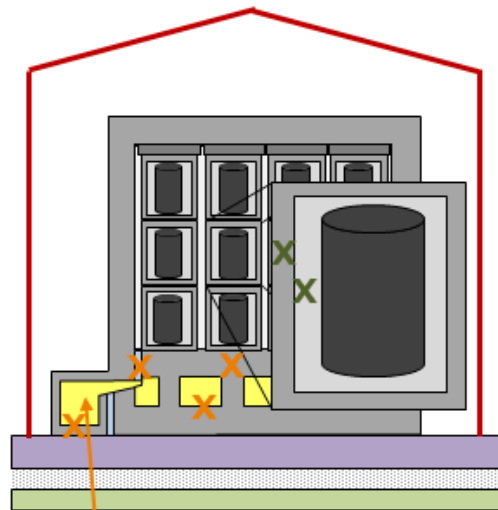
Phase Ia

Phase Ib

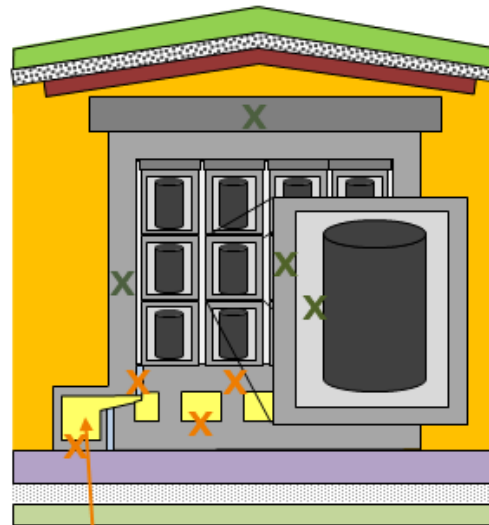
Phase II

X: normal operating conditions

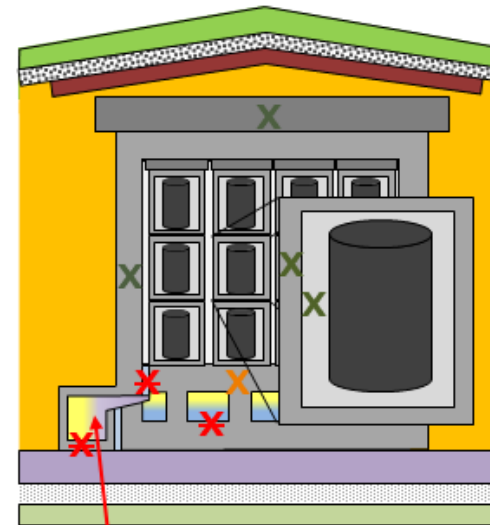
X: deviating operating conditions



collect water and drain towards WCB/BP



collect water and drain towards WCB/BP



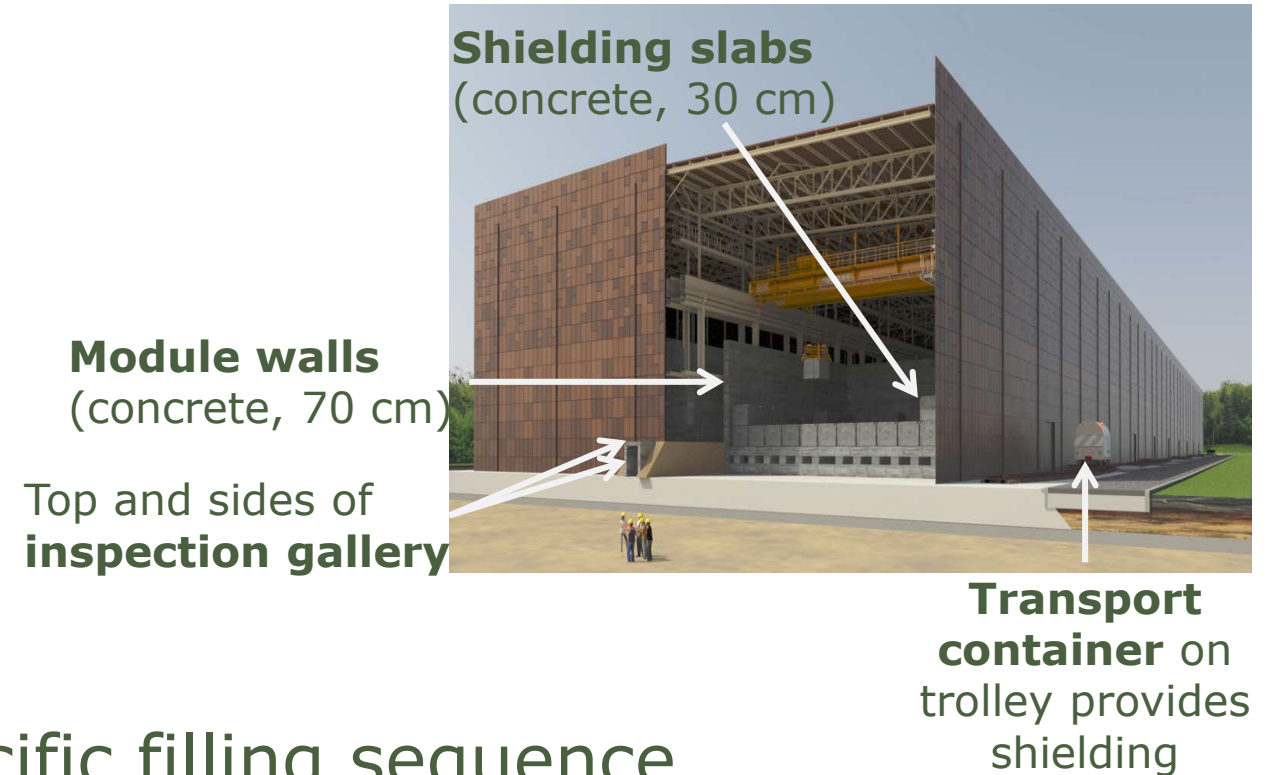
collect and drain towards WCB/BP

Limiting external irradiation

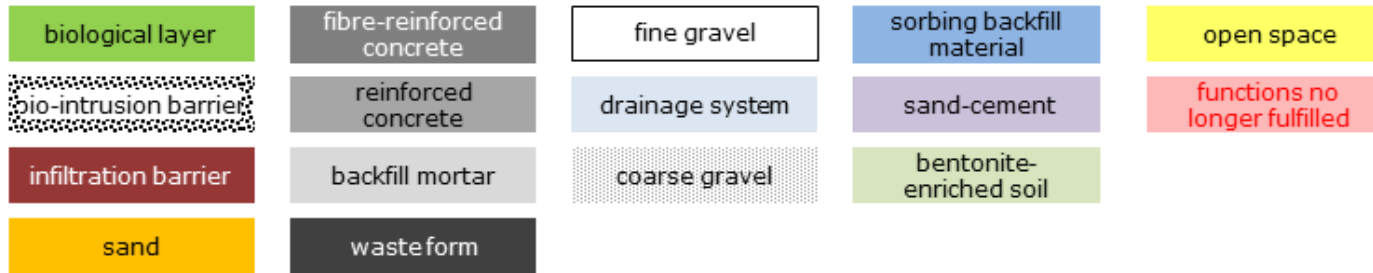
- **Operational radiation protection**
- **Shielding** by SSCs surrounding the waste
- **Isolation** by means of
 - ◆ barriers creating distance
 - ◆ collective measures
 - remote-controlled operations
 - fencing (controlled zone, disposal site)
 - ◆ individual measures
 - access controls (controlled zone, disposal site)
 - work permits

Shielding practices

- Shielding by mortar and caisson → **contact dose rate** limited to 20 mSv/h
- To the extent possible: **further** shielding of monoliths
- **Self-shielding** through specific filling sequence
 - ◆ Limited dose rate per layer of monoliths
 - ◆ Additional restrictions on topmost layer
 - ◆ More strongly radiating monoliths in the centre

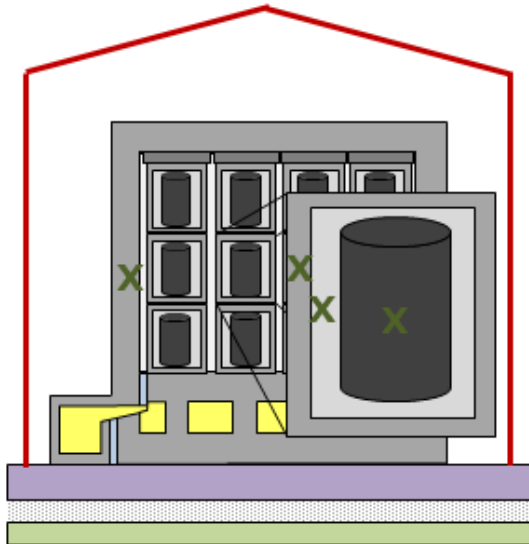


Isolation (w.r.t. intrusion)



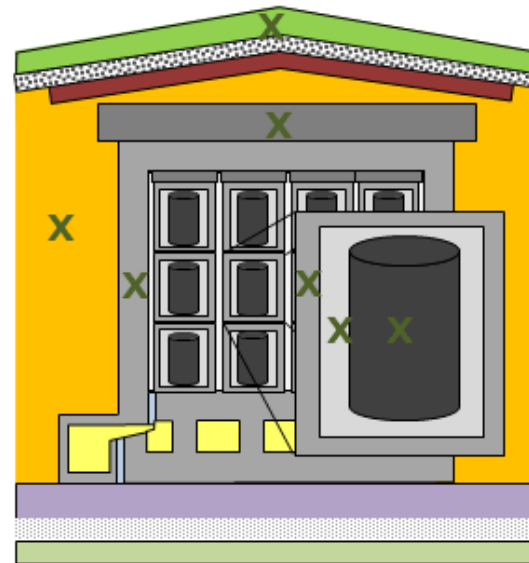
Phase Ia

Access control
Fencing around the site



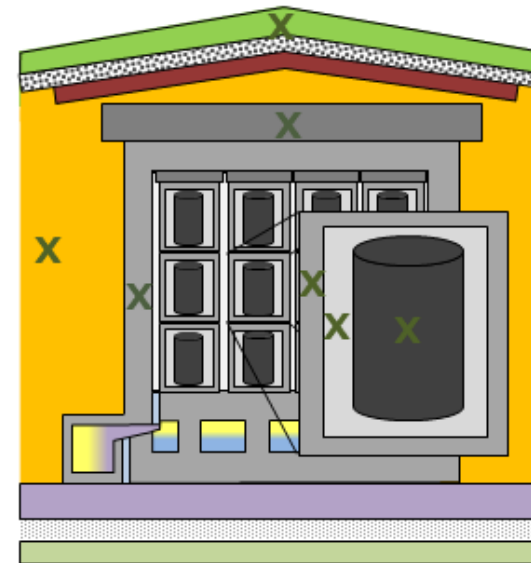
Phase Ib

Access control
Fencing around the site



Phase II

Access control
Fencing around the site



Protection

- Against threats/perturbations
 - ◆ to strengthen the fulfilment of operational safety functions
 - fire detection/fighting
 - SFP-crane
 - emergency supply
 - ◆ to ensure that long-term safety functions can be met
 - cover
 - foundations



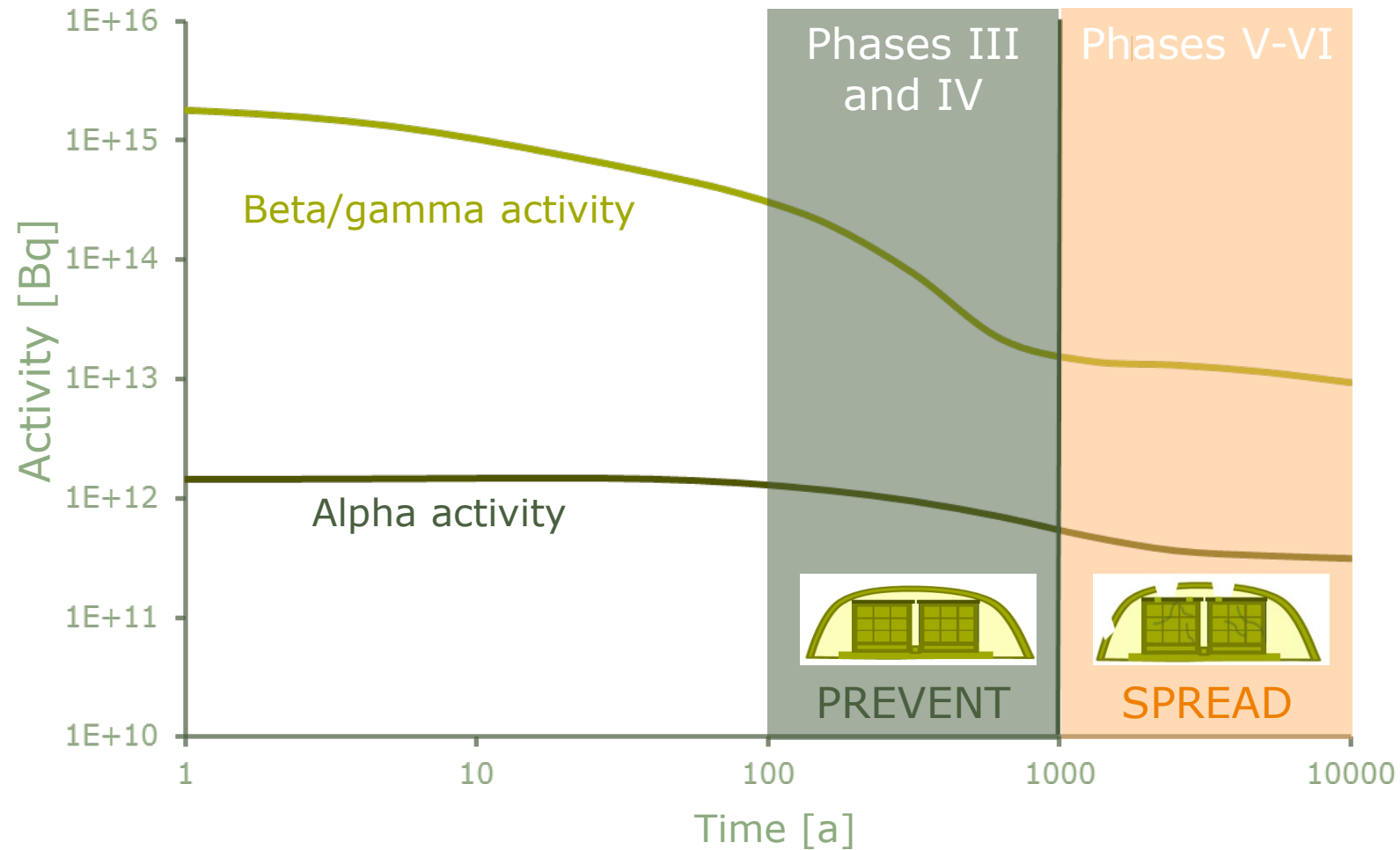
Long-term safety concept

Safety concept timeframes



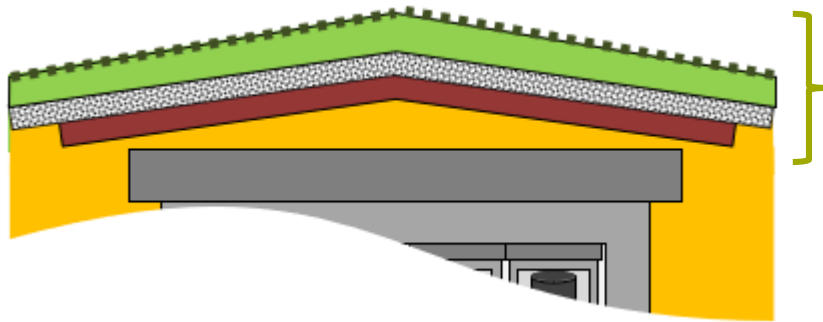
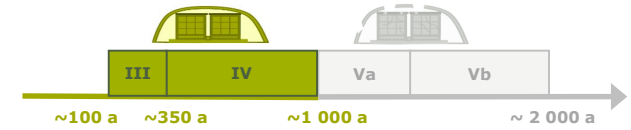
Containment

Graded approach \sim residual hazard

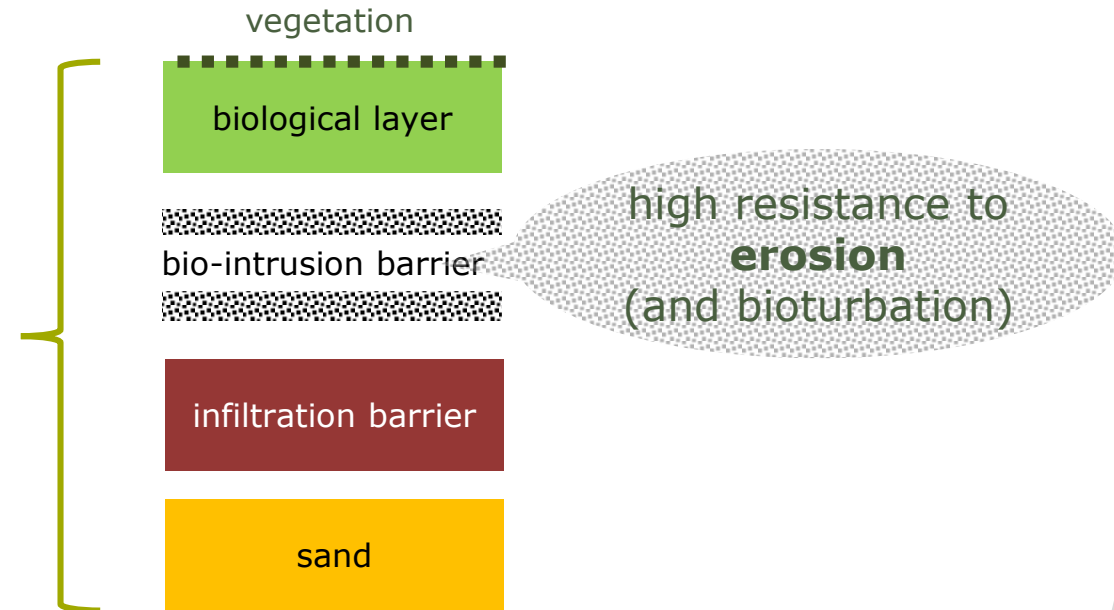


Earth cover

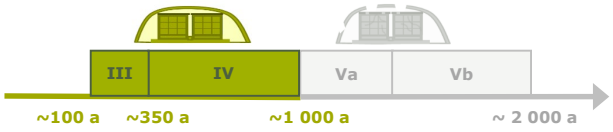
Protection of concrete SSCs for ~ 1000 years



**BURIED
CONDITIONS**



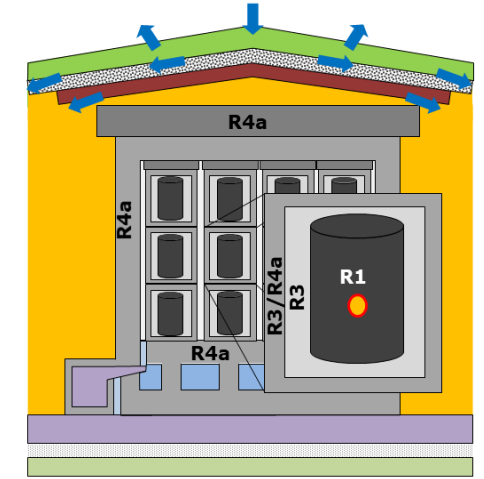
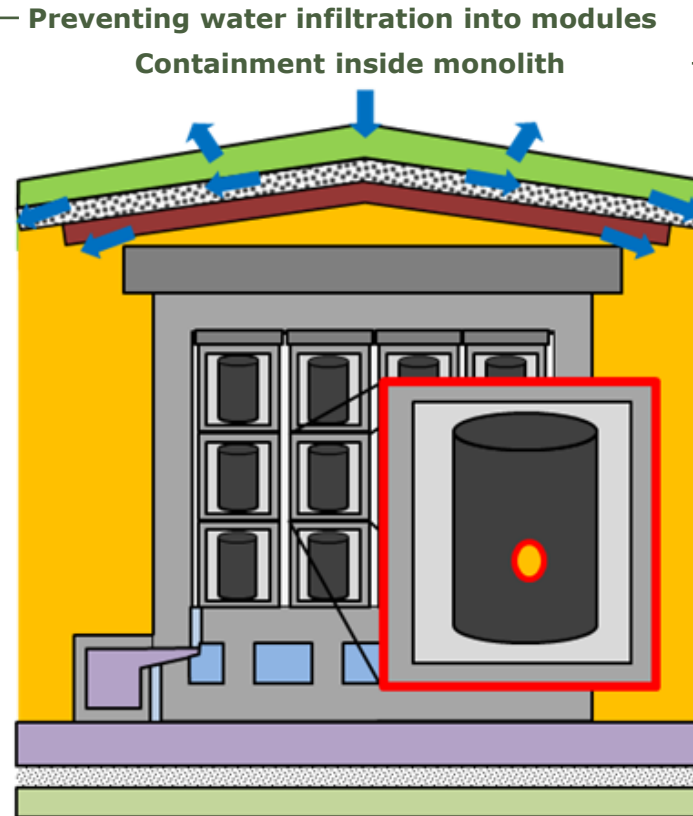
Containment < \sim 1000 years



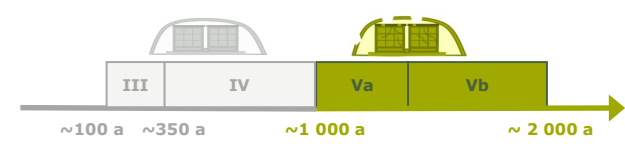
Phases III and IV - Preventing radionuclide release

Preventing water infiltration into modules
Containment inside monolith

< Limiting water infiltration towards the waste (R2a)

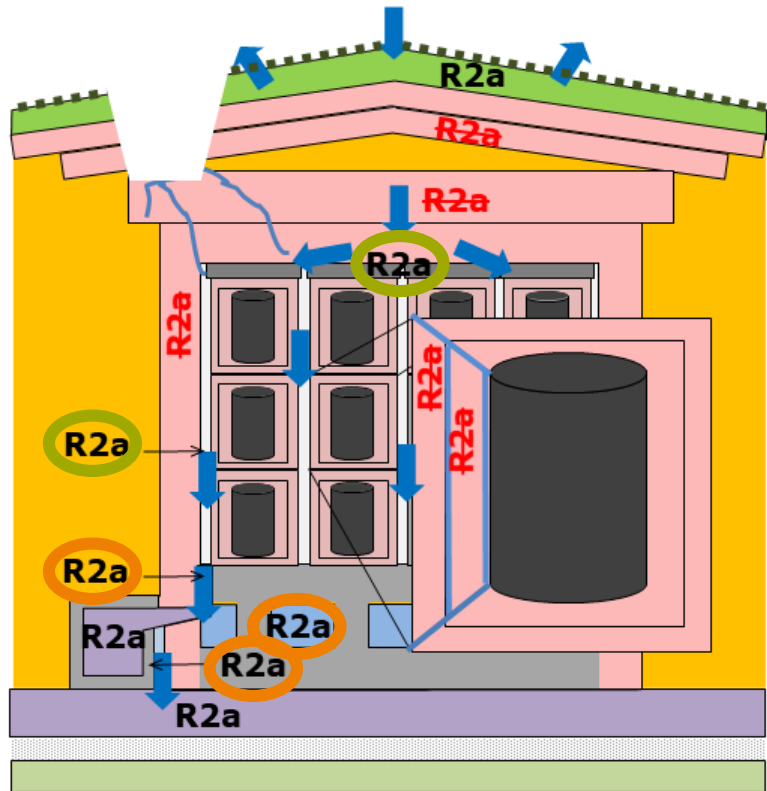


- Limitation of releases from the waste (R1)
- Sorption in backfill mortar/caisson (R3)
- Limited diffusion towards/in caisson and surrounding SSCs (R4a)



Containment > ~1000 years

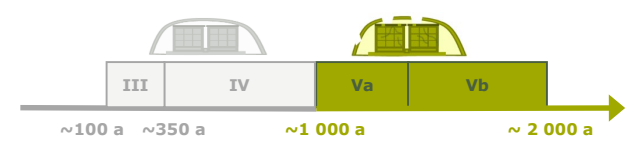
Phases Va/b - Limited water infiltration towards the waste (R2a)



- Water infiltration into the modules can no longer be prevented
 - restricted only through evapotranspiration on earth cover remnants

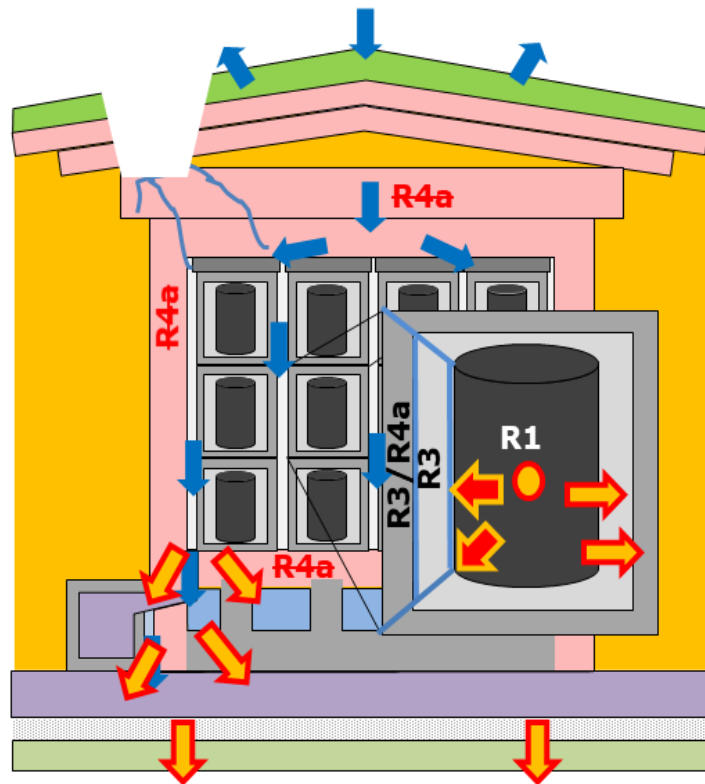
- **Preferential** flow in inter-monolith spaces

- **Anti-bathtub system**
 - sand-cement to ensure further drainage



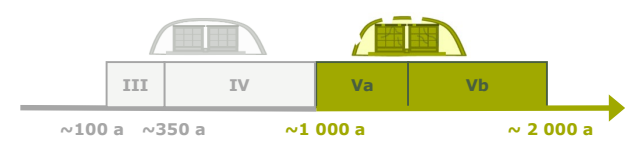
Containment > ~1000 years

Phases Va/b – Containment inside monolith



Releases from monoliths further continue to be limited and spread by

- Slow release from the waste (**R1**)
 - Sorption on cement
 - Waste characteristics
- Sorption in backfill mortar and caisson (**R3**)
- Slow diffusion in caisson (**R4a**)

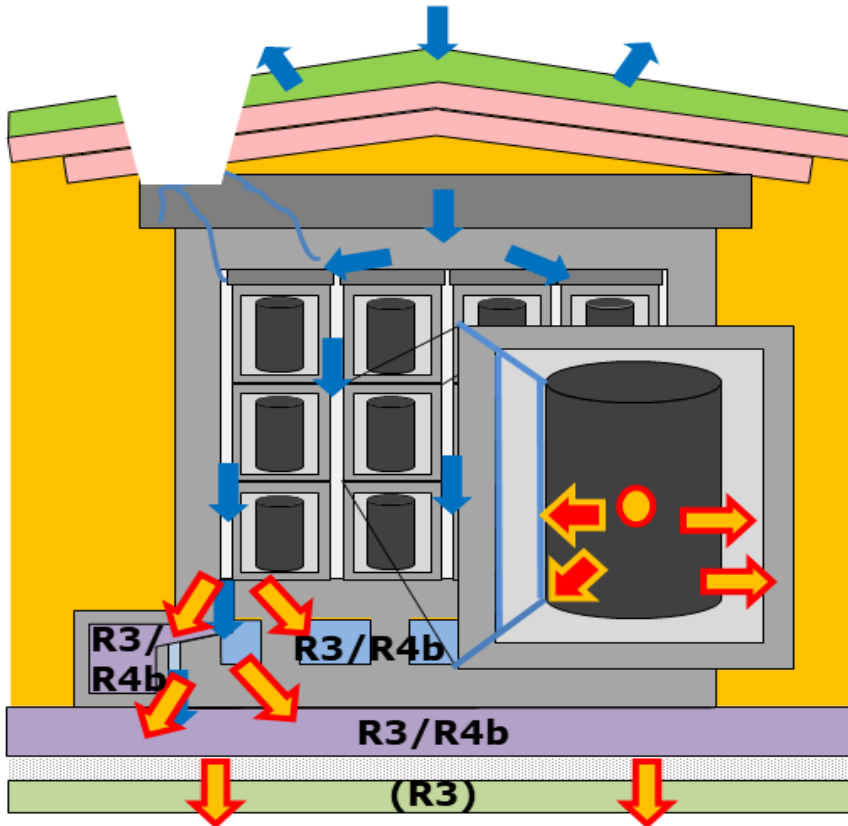


Containment > ~1000 years

Phases Va/b – Spreading and retardation outside monolith

Fractures as preferential transport routes

→ **bypass**

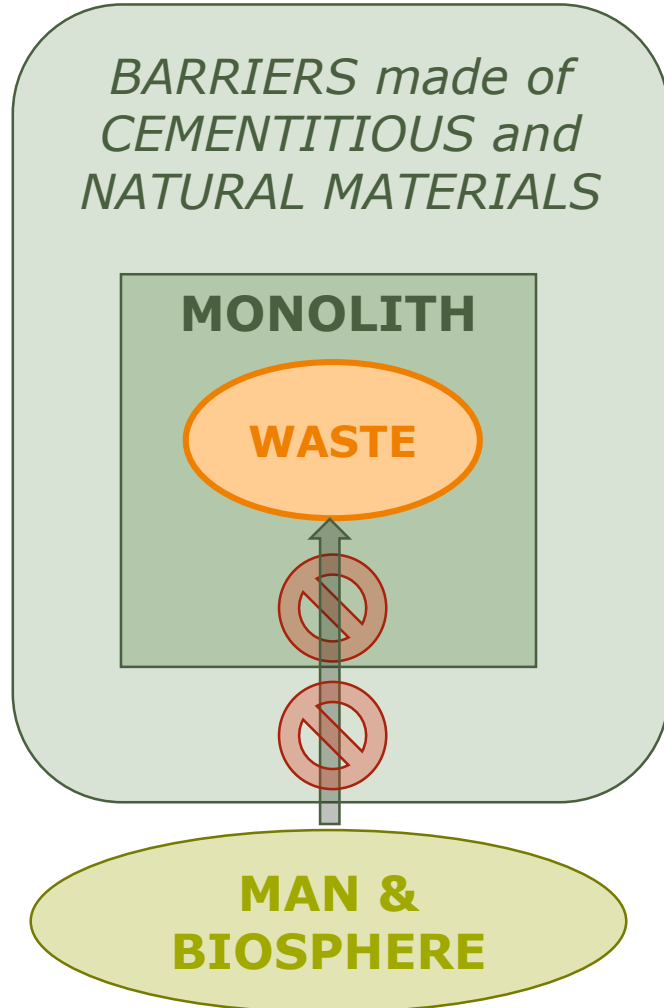


Conductive sorbing media spread the release of radionuclides from the system

- Spreading by **dispersion** in conductive material (**R4b**)
- **Sorption** in conductive material (**R3**)

Isolation

Prevent direct contact between man and waste

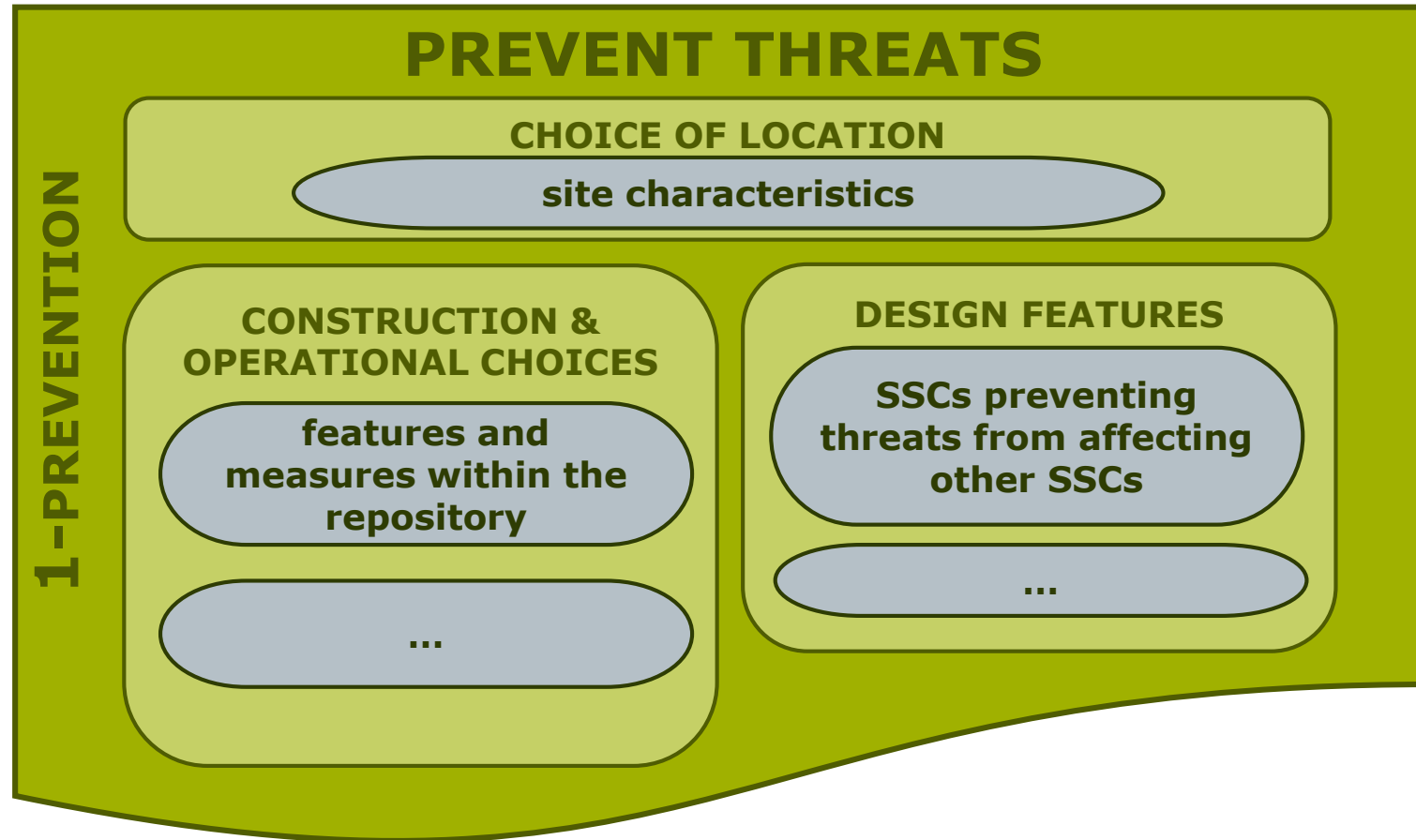


- disposal system configuration ensures isolation in absence of direct threats (e.g. intrusion)
→ **no direct contact**
- Surface disposal → possibility of inadvertent intrusion → **safety function I1**
 - ♦ $t < 350$ years (end of phase III): access restrictions
 - ♦ Phases III/IV: barriers around the waste render intrusion difficult and limit its consequences
 - Earth cover & side embankment
 - Concrete SSC's
 - Monoliths

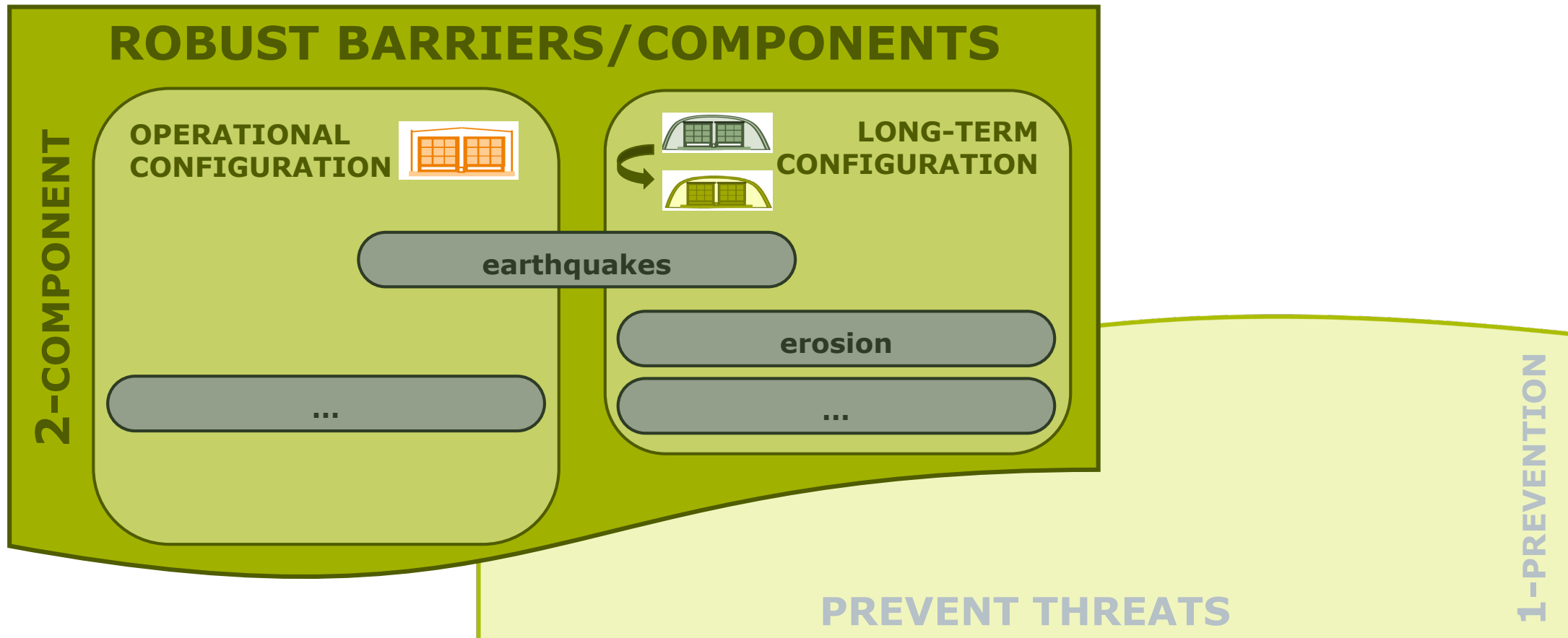


Defence in
depth

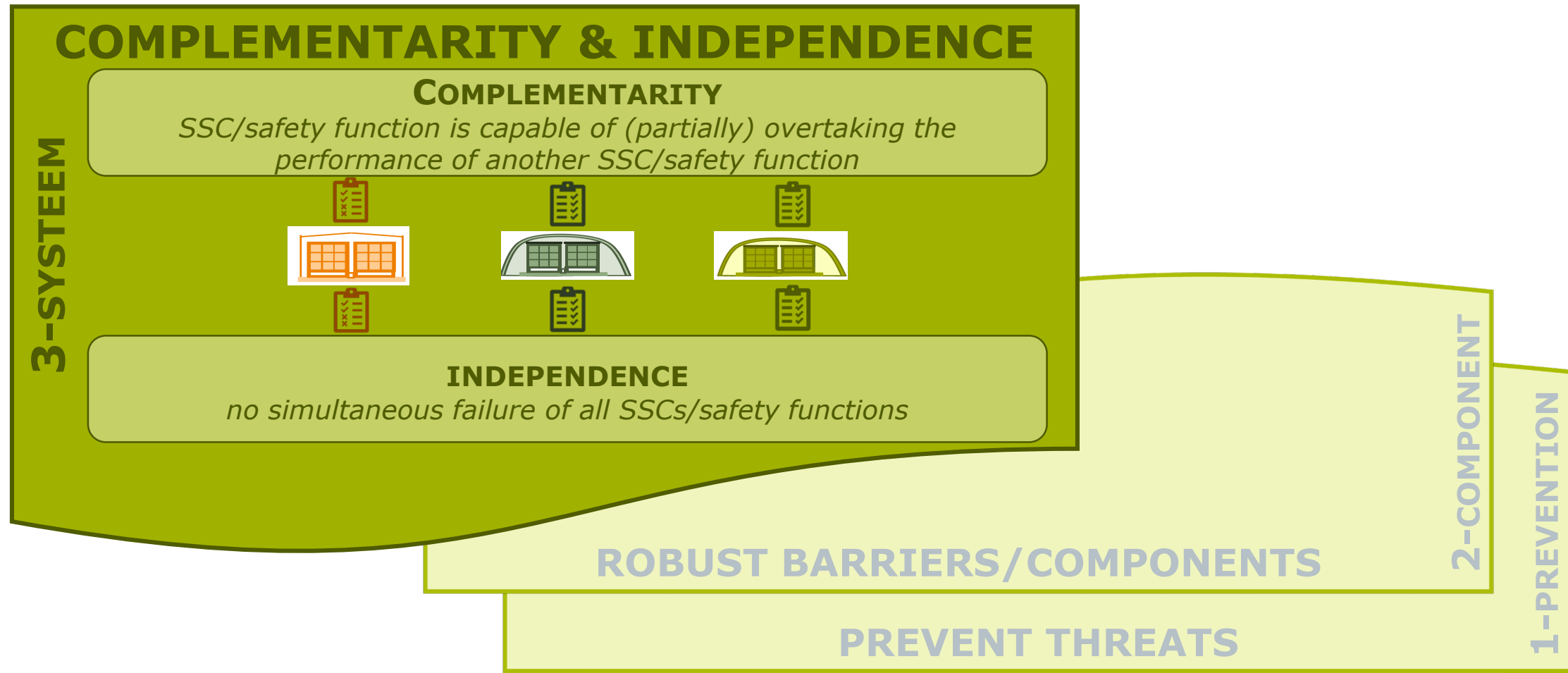
Level 1 : Prevention



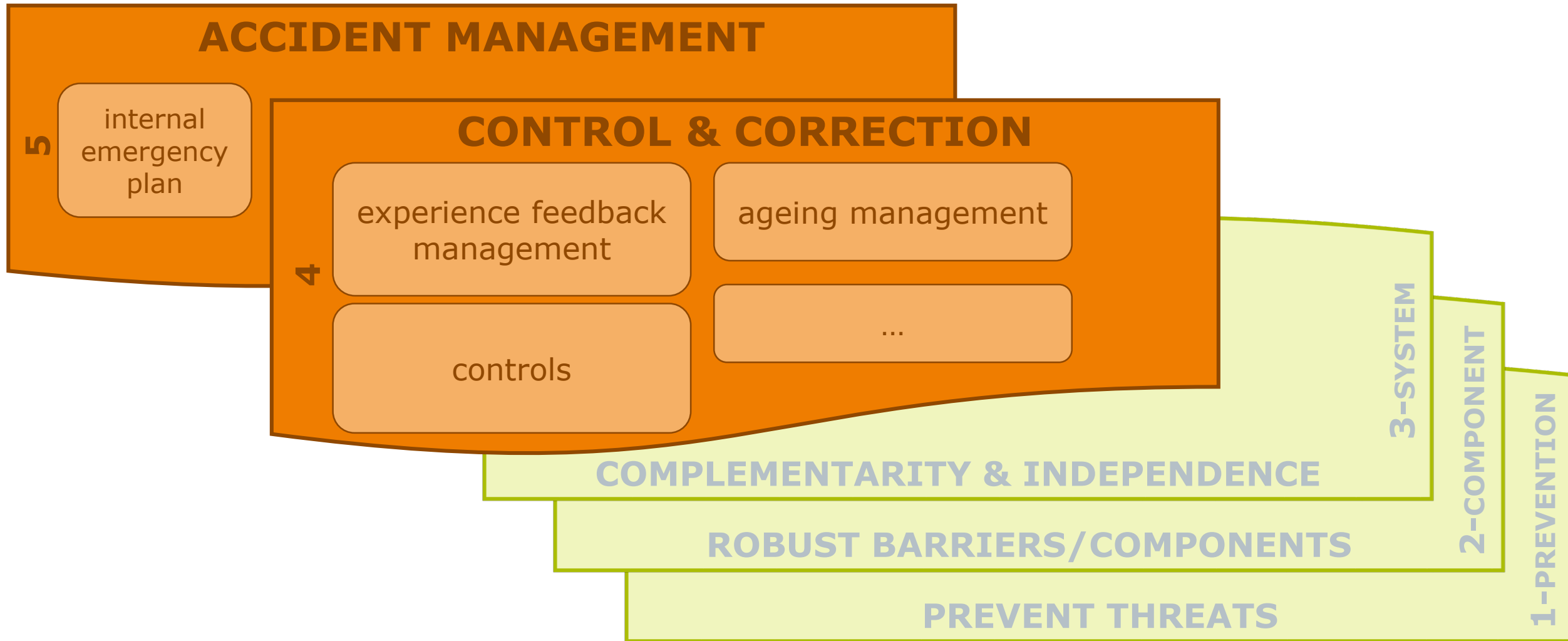
Level 2 : Component



Level 3: Disposal system



Level 4/5: "operational" measures



Humans and the environment are protected, now and in the future, by

- restricting the amount of long-lived radionuclides in the waste;
- radiation protection management;
- isolating the waste from the biosphere and contain the radionuclides;
- subsequent and independent elements of protection (defence in depth).