

THE PROJECT OF THE CENTURY FOR NUCLEAR WASTE IN SWITZERLAND

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nagra.



1. BASICS

2. SITE SELECTION & RESULTS

3. REALISATION

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WE HAVE WASTE IN SWITZERLAND

- 4 nuclear power plants
- (5 reactors)
- Medicine, industry and research
- Around 80,000 m³ of packaged waste
- Central interim storage



NAGRA

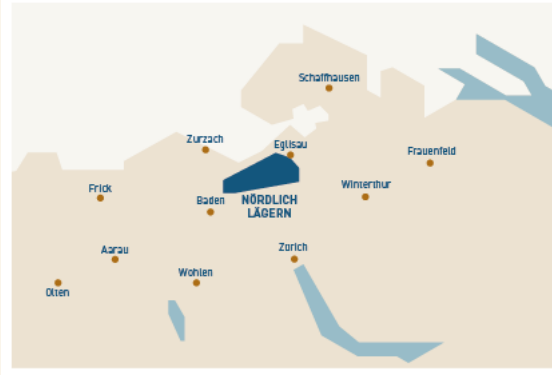
- Nuclear waste producers established Nagra in **1972**
- Around **130 employees**, mainly scientists and engineers
- Yearly budget approx.: 50 (– 100) Million Swiss Francs
Cost contained in electricity price: approx. 1 €-Cent per kWh
- Financed by the waste producers:
Nuclear Power Plants 92%
Government 8%
- Waste:
High-level waste 9'300 m³
Low- & intermediate-level waste 72'000 m³



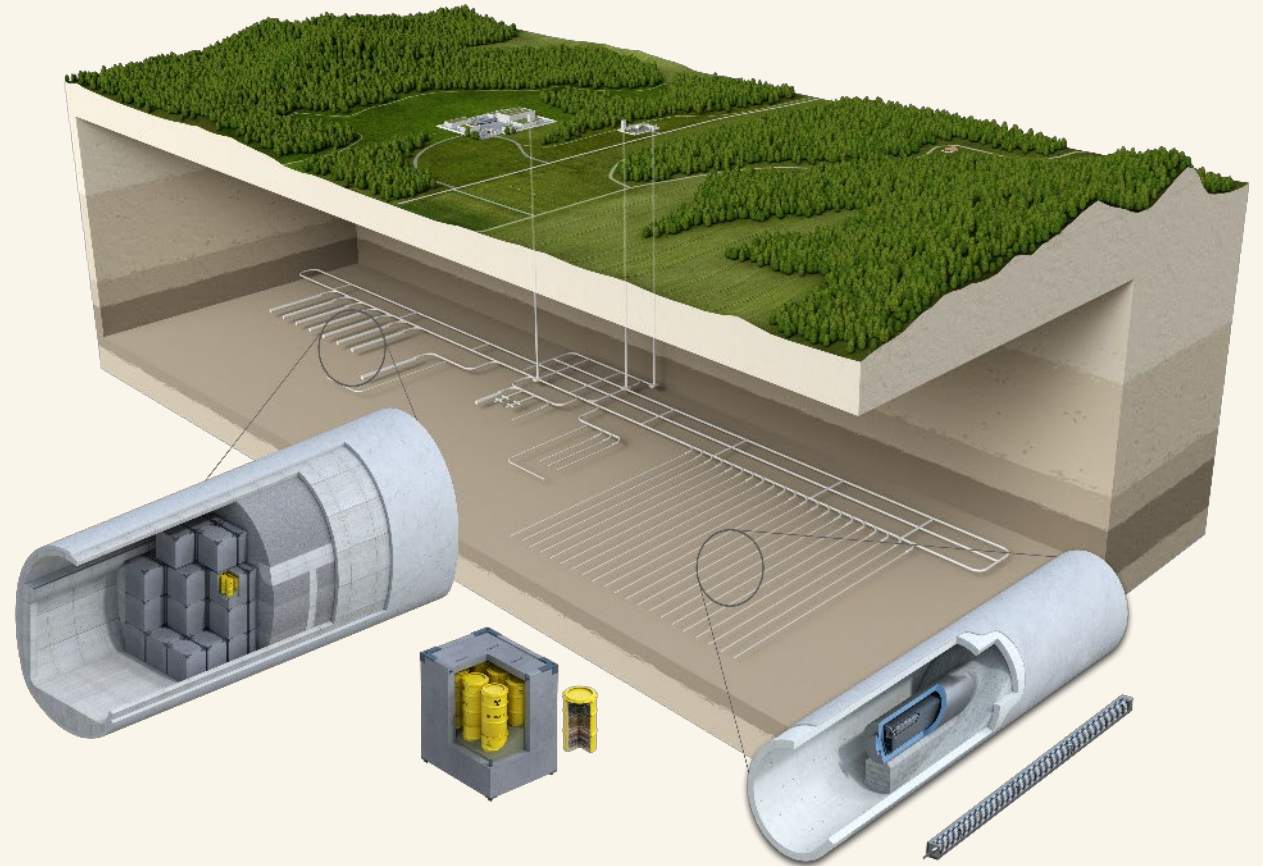


COMBINED REPOSITORY

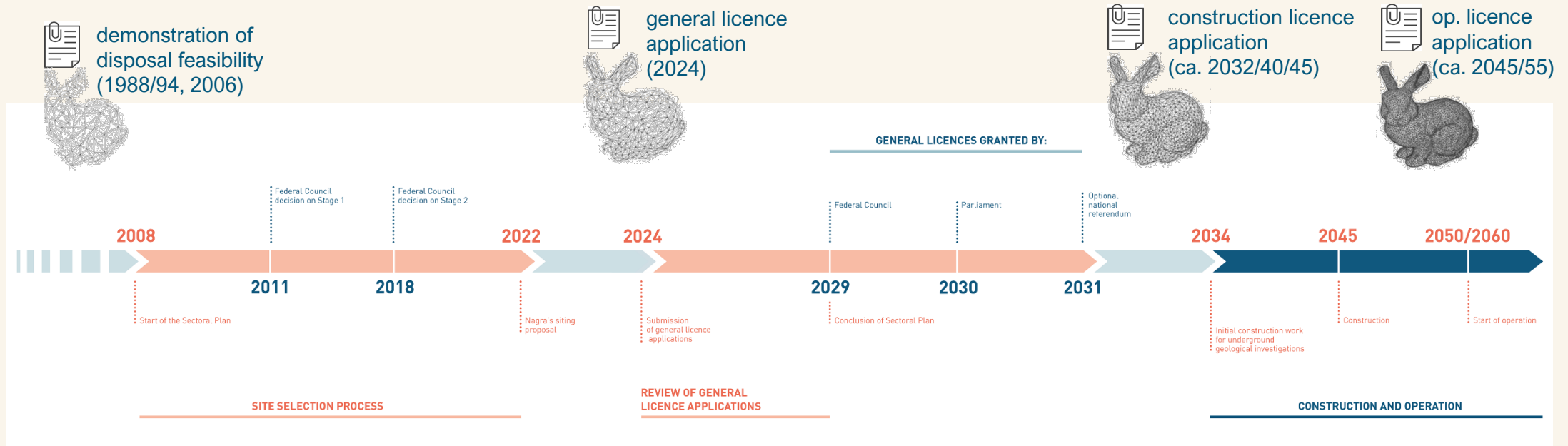
NAGRA'S SITING PROPOSAL



VISUALISATION
OF THE SURFACE FACILITY



THE FUTURE...





1. BASICS

2. SITE SELECTION & RESULTS

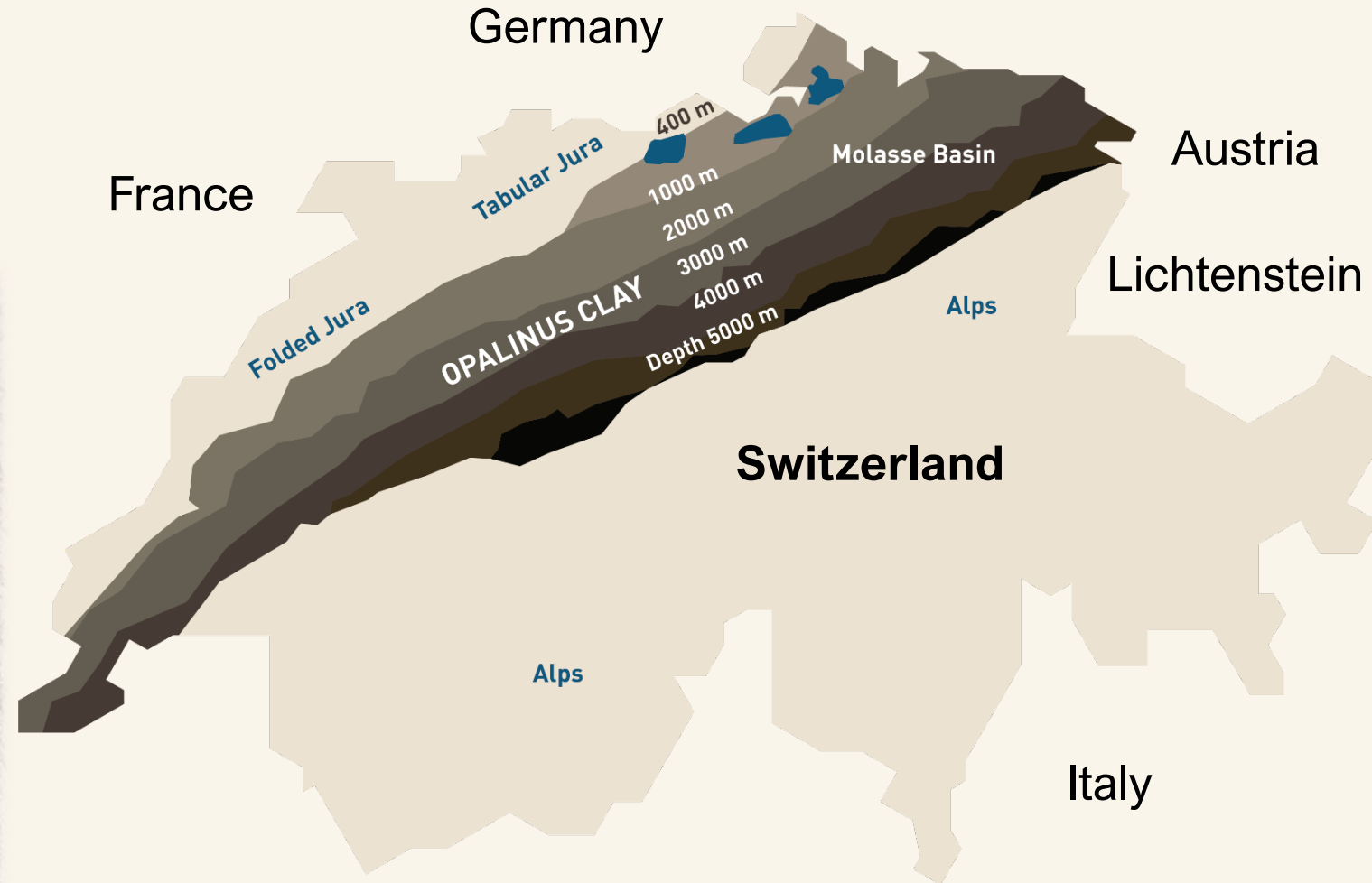
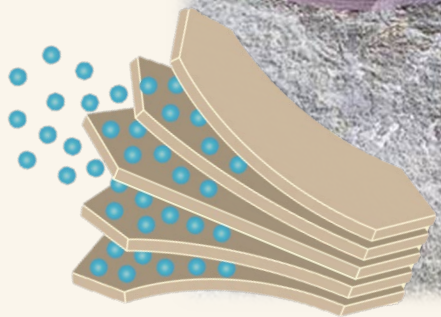
3. REALISATION

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OPALINUS CLAY = HOST ROCK IN SWITZERLAND

- Swellable clay minerals
- Sorption capacity
- Very low permeability
- Homogenous layer

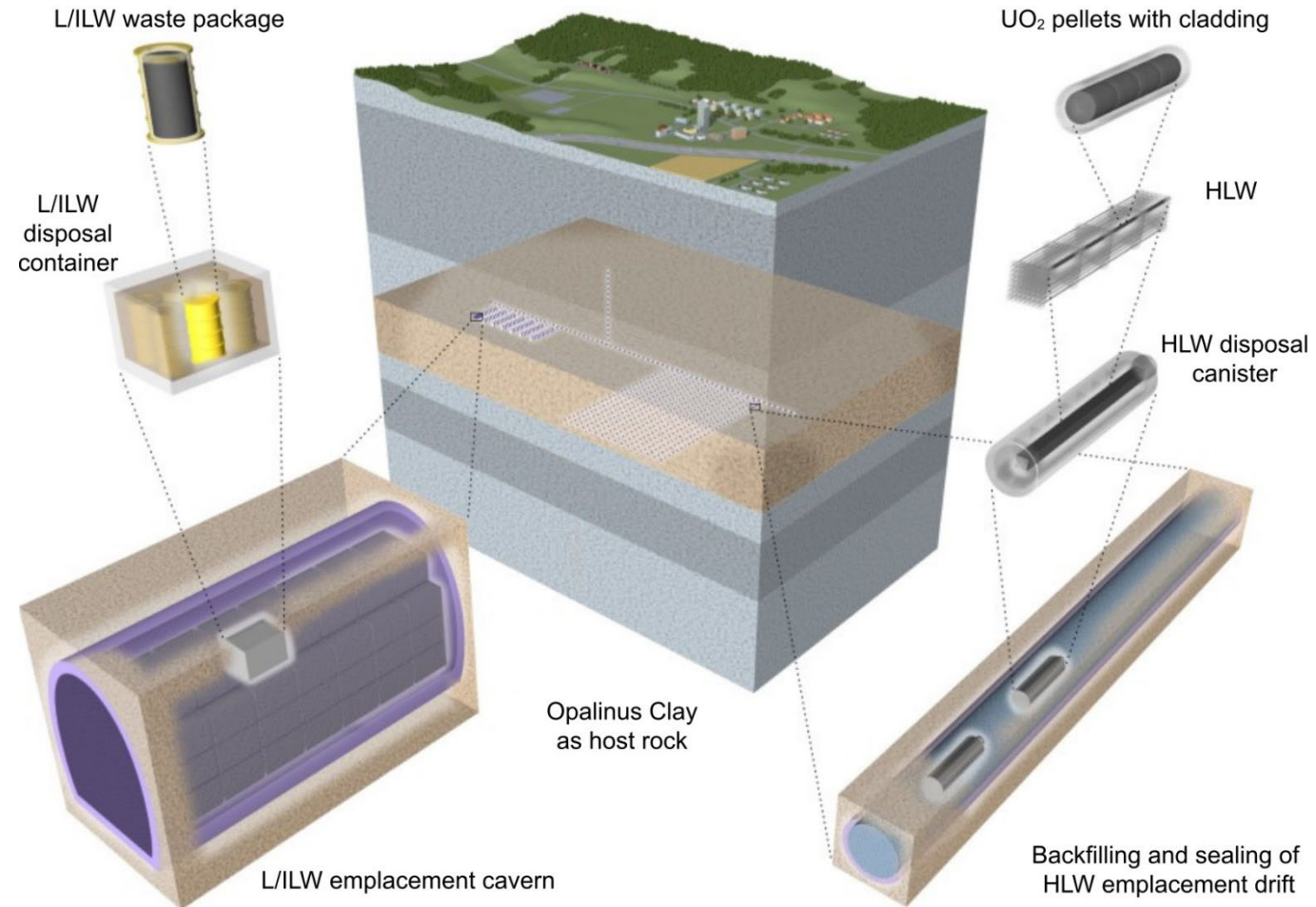


THE SAFETY CONCEPT - KEG

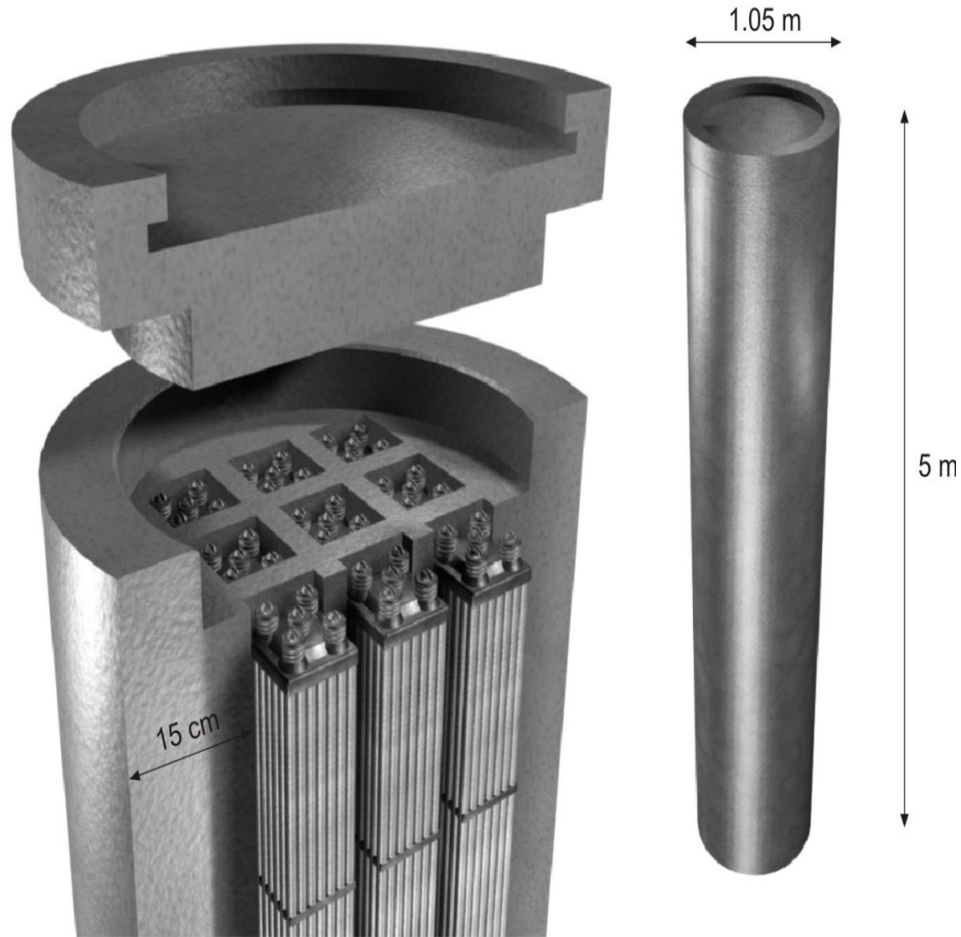
(§ 3c KEG):

«The **safety concept** illustrates **how** the **protection** objective is **achieved** through multiple, sequential and passive barriers»

Implementation of the Swiss safety concept that consists of a safety-optimised multi-barrier system.



PILLARS OF SAFETY ENSURE SAFETY FUNCTIONS – EXAMPLE 1



The spent fuel disposal canister

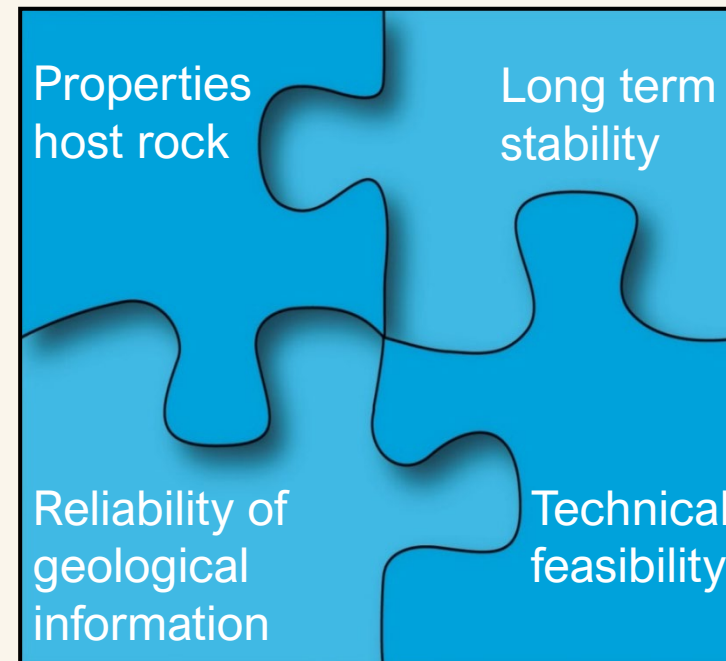
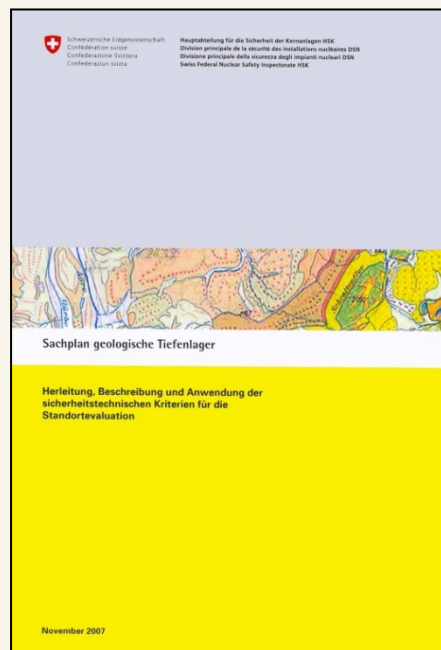
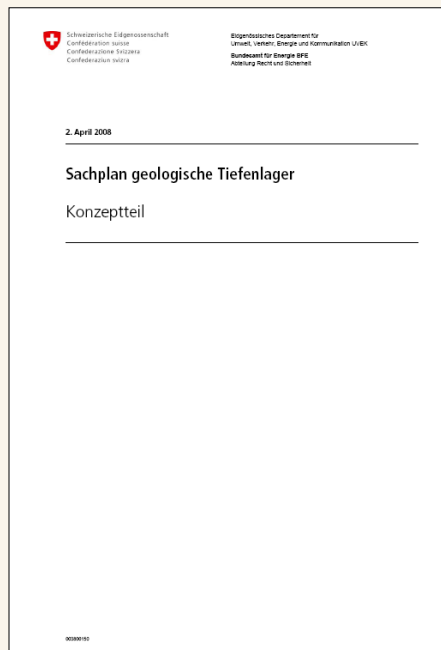
Provides **containment** for >10'000 years

Contributes also to **immobilisation, retention** and **slow release**

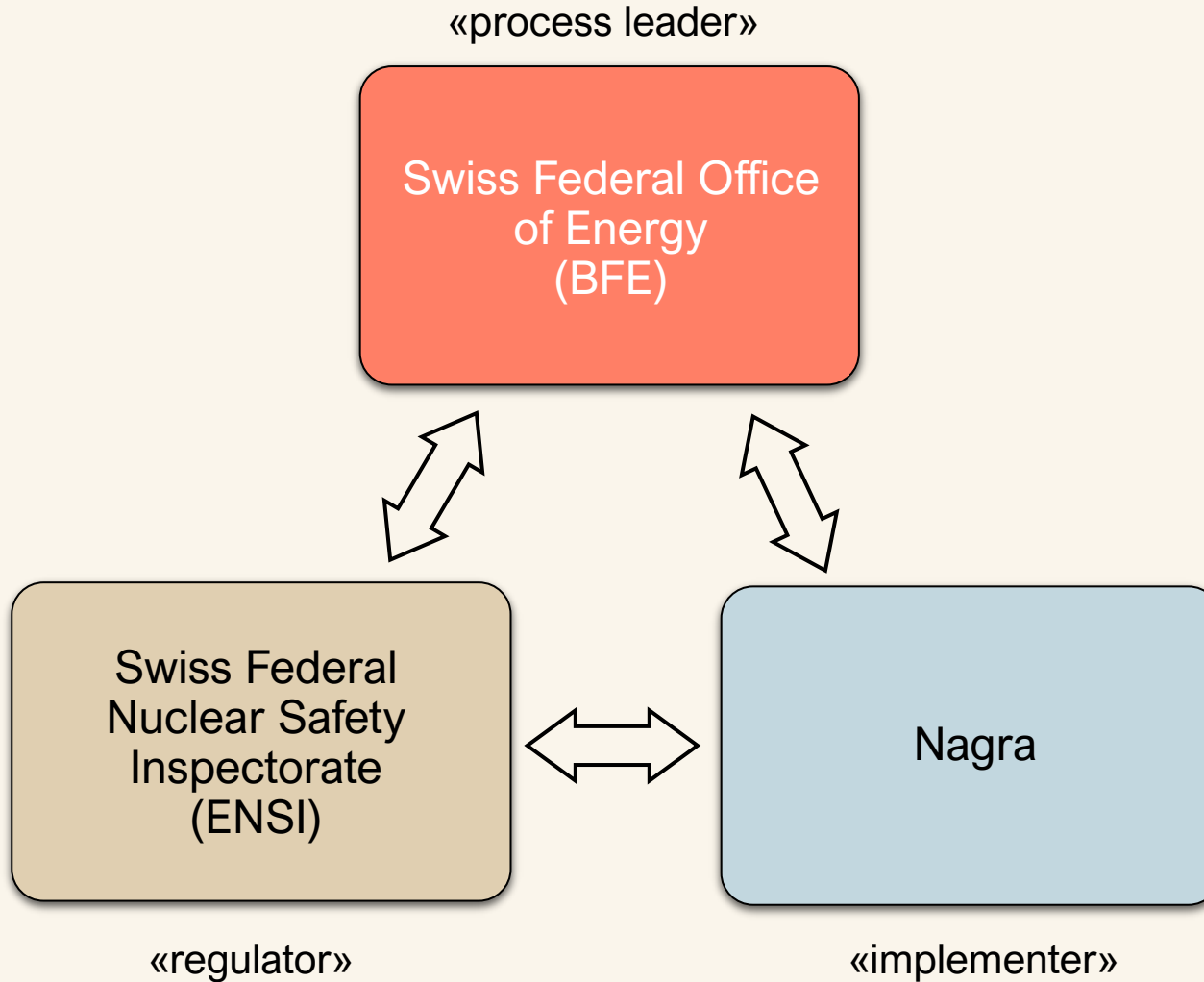
Is **compatible** with other barriers

THE 'SECTORAL PLAN': RULES FOR SITE SELECTION

- The documents
 - Process & responsibilities
 - Criteria (safety, environmental impact, socio-economic issues)
 - Safety: 13 technical criteria (4 interrelated groups)



ROLES - OVERVIEW

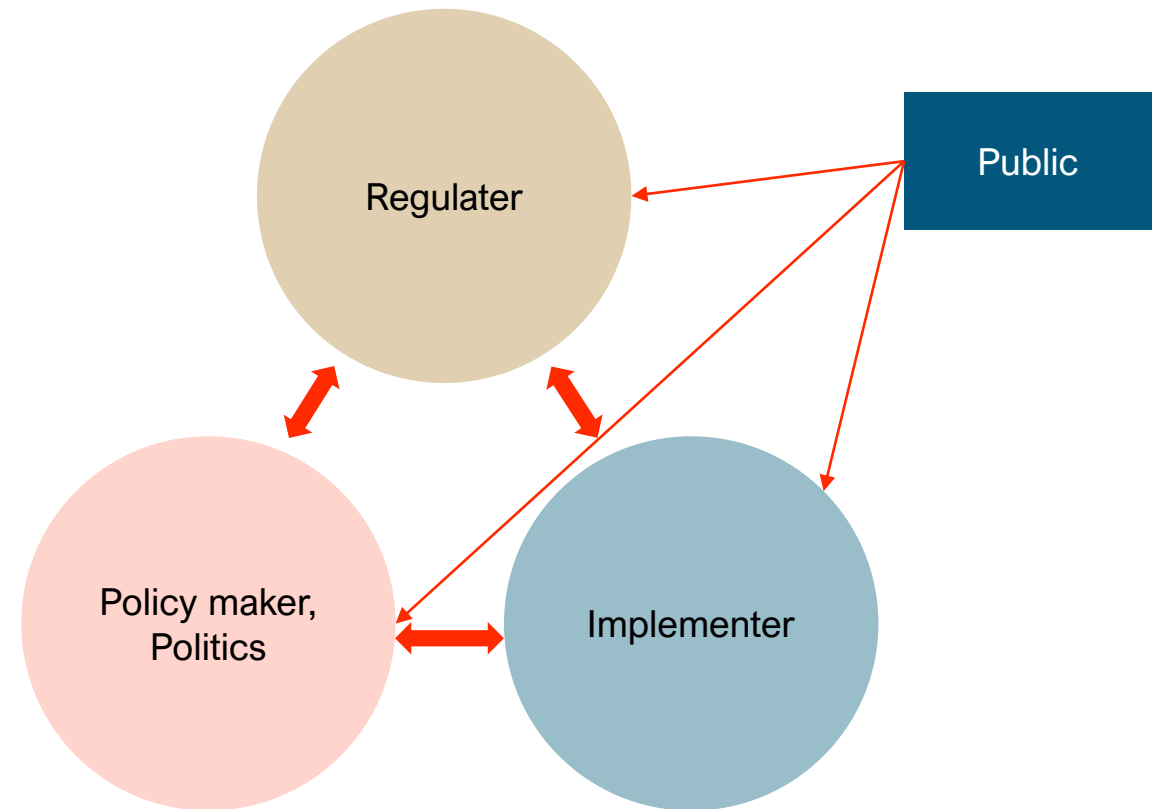


DECISION-MAKING PROCESS: **TRUST** & **CONFIDENCE** ARE CRITICAL FOR SUCCESS

Sound projects (implementer, based on sound science)

Clear and separate roles: importance of a strong & ***independent regulator*** (criteria, review & supervision)

Policy with an ***adequate framework***: clear goals, defined & well managed process, continued political support



Building trust & confidence

➔ Formal interaction and involvement of (& perception by) the public

INSTRUMENTS

Instruments to meet special information needs of political bodies and siting regions:

- Regular information on work results (federal, cantonal and local level)
- Involvement of local authorities through regional conferences
- Visits to Nagra's field investigations (e.g. deep boreholes)
- Events and trade fairs in or close to siting regions (personal dialogue)
- Participation of Nagra staff at public events or at events organised by interested groups and organisations
- Information platform and website



CLEARLY DEFINED RULES: TRANSPARENT CRITERIA

Criteria for site evaluation from the viewpoint of safety and technical feasibility

Criteria group	Criteria
1. Properties of the host rock and the effective containment zone	1.1 Spatial extent 1.2 Hydraulic barrier effect 1.3 Geochemical conditions 1.4 Release pathways
2. Long-term stability	2.1 Stability of the site and rock properties 2.2 Erosion 2.3 Repository-induced influences 2.4 Conflicts of use
3. Reliability of geological findings	3.1 Ease of characterisation of the rock 3.2 Explorability of spatial conditions 3.3 Predictability of long-term changes
4. Engineering suitability	4.1 Rock mechanical properties and conditions 4.2 Underground access and drainage

SITE SELECTION PROCESS – TIMING AND STEPS

START OF THE SECTORAL PLAN



RESULTS OF STAGE 1



■ siting regions

RESULTS OF STAGE 2



NAGRA'S SITING PROPOSAL



Start of the Sectoral Plan 2008

Federal Council decision on Stage 1 2011

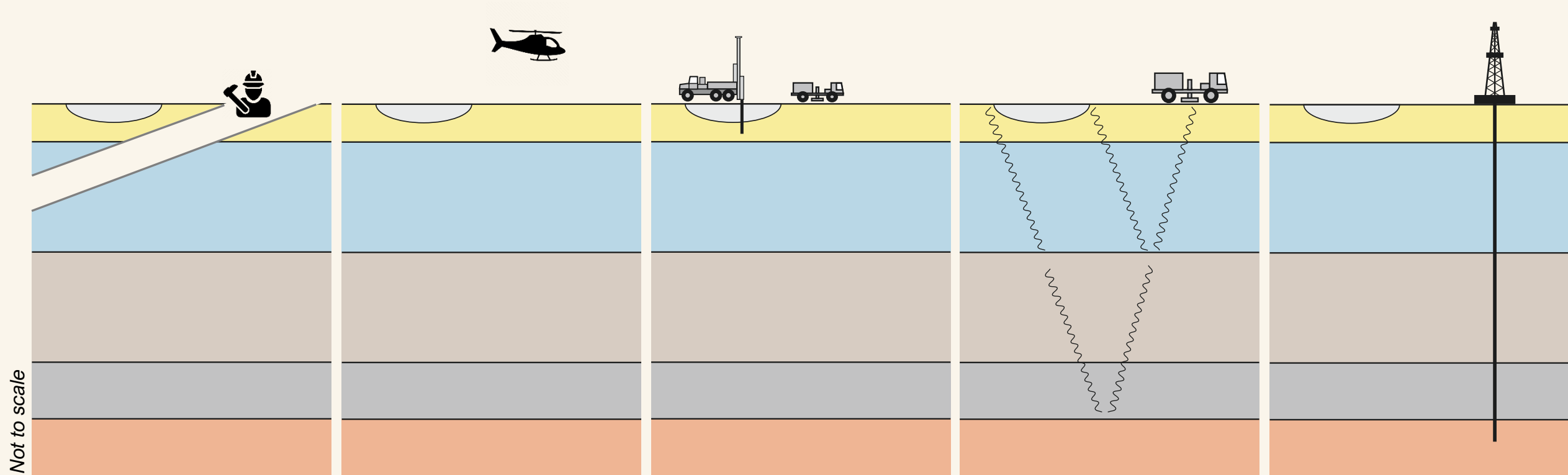
Federal Council decision on Stage 2 2018

Nagra's siting proposal 2022

Submission of general licence applications 2024



MAIN EXPLORATION METHODS



Mapping
(incl. tunnels)

Air-borne
investigations

Near-surface
investigations

2D & 3D
Seismics

Exploration
boreholes

including participation in third party projects (e.g. geothermal)

GEOLOGICAL INVESTIGATIONS OF STAGE 2



Investigation in third party drill holes
→ broadened rock data base

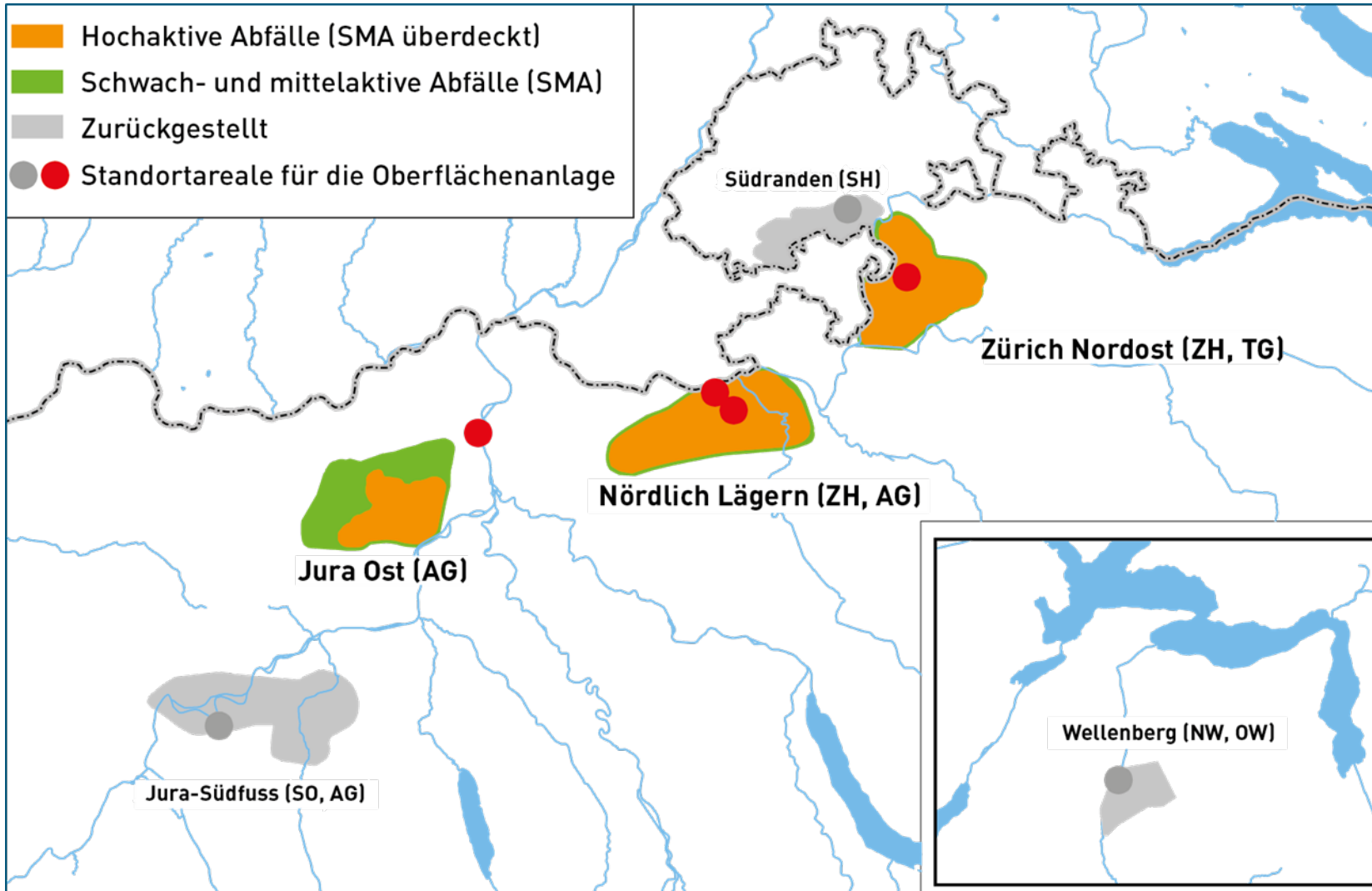


Fill-in 2D-seismic survey and reprocessing of legacy surveys
→ improved and homogenized structural data base



Quaternary deposits: compilation and analysis of existing data;
process studies; modelling work;
→ landscape evolution scenarios
→ process understanding (e.g. drainage evolution, ice flow,
subglacial hydrology)

RESULTS STAGE 2 (FEDERAL GOV 21.11.2018)



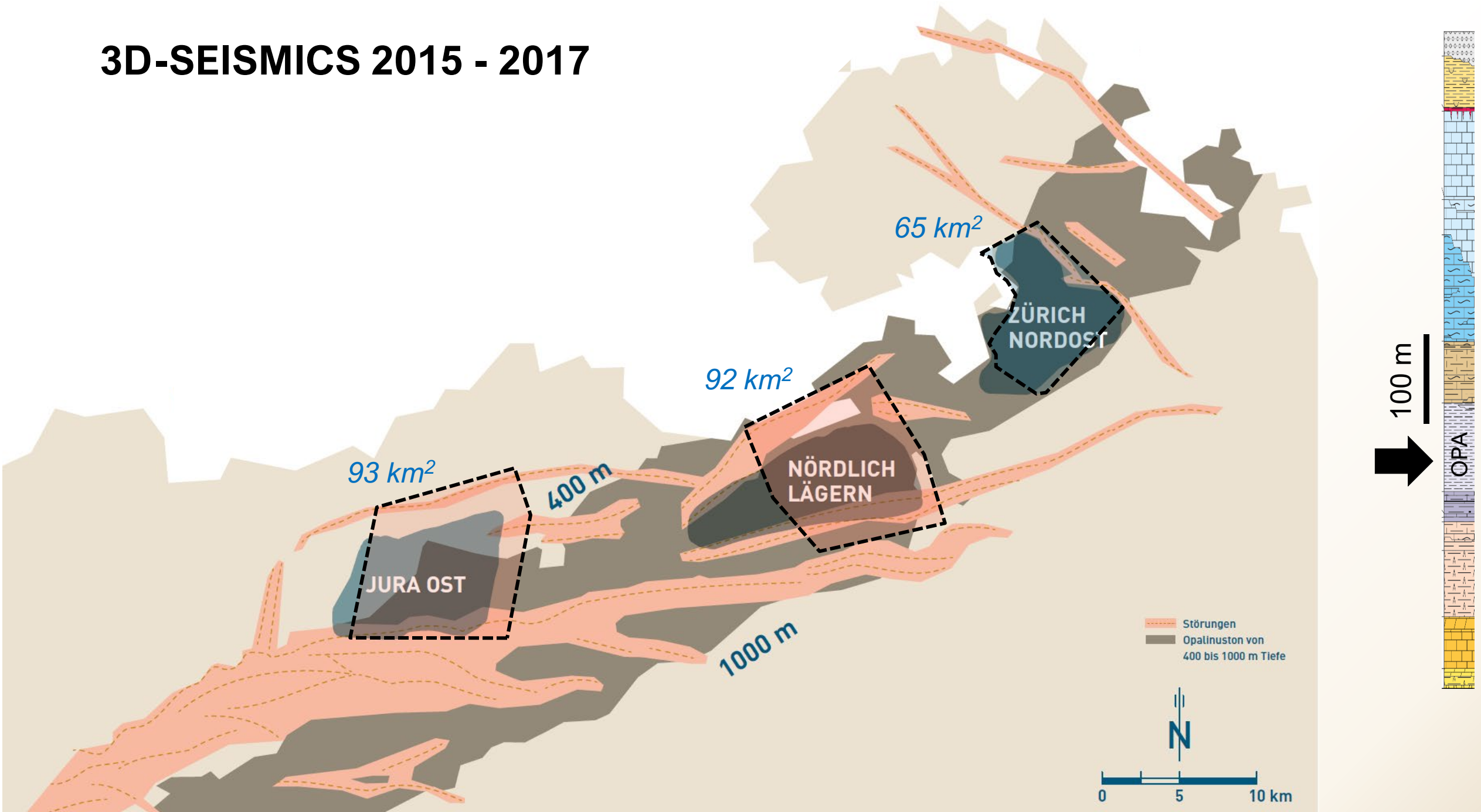
- 2014 Nagra proposed 2 regions
- 2015 Expert commissions and regulator brought back a third region
- 2018 Federal Gov. Decision: 3 regions

Regulator (ENSI) and Fed. Gov. did not follow Nagra's proposal to set aside the deepest site (Nördlich Lägern). Did that strengthen or weaken the site selection process?



3D SEISMICS

3D-SEISMICS 2015 - 2017





DRILLING

EXPLORATION BOREHOLES

- Drilling duration: 2019 until 2022 = 36 months
- **9 exploration boreholes** (of which 1 deviated)
 - shallowest: ca. 830 m deep
 - deepest: ca. 1'370 m deep
- in **total ca. 10'740 m drilled**
(of which ca. 1'040 m in Opalinus Clay)
 - ca. 60% cored
- ca. **4'600 drill core samples**
- ca. 65'000 m geophysical wireline logging
- ca. **140 micro-hydraulic fracturing tests**
- **94 hydraulic packer tests**
(of which ca. 35 in Opalinus Clay)
- 6 gas threshold pressure tests
- No interruption due to COVID
- **No serious accidents**

22.06.2023



4500 SAMPLES

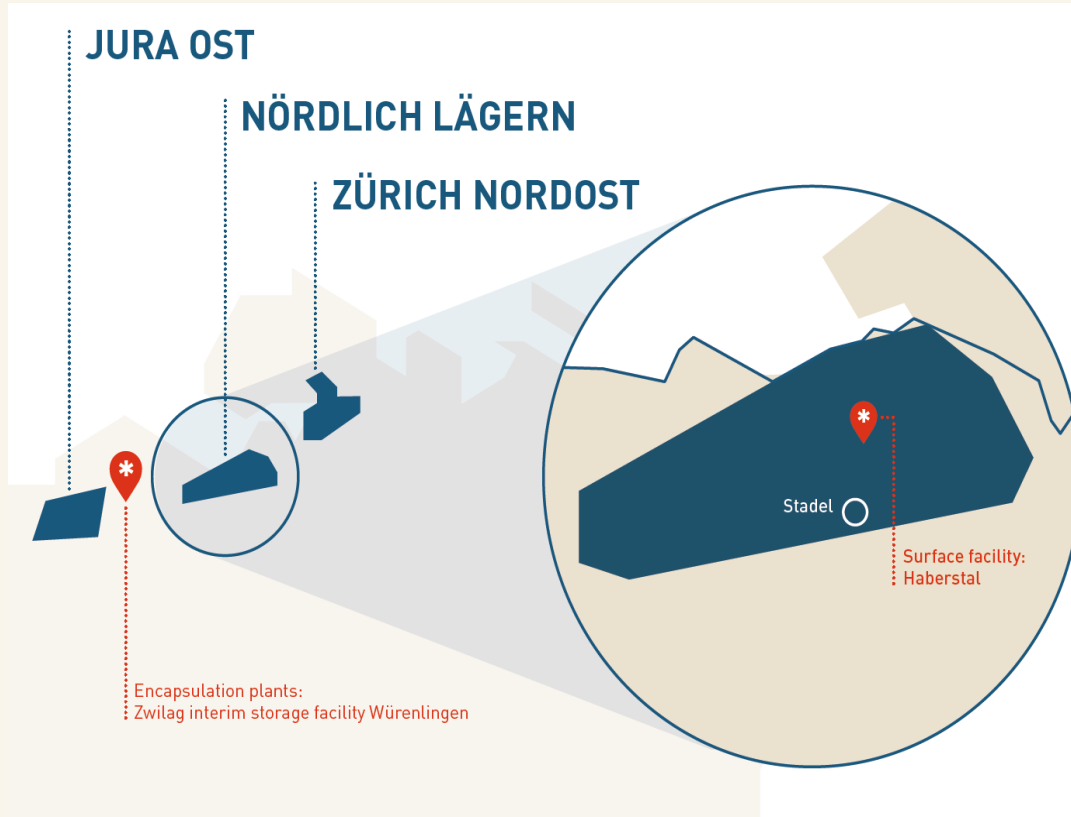
LANDSCAPE EVOLUTION SCENARIOS



SITE ANNOUNCEMENT: “GEOLOGY HAS THE FINAL SAY”

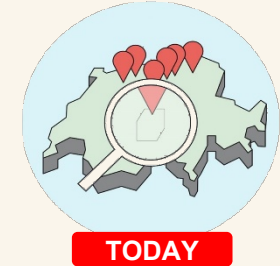


ANNOUNCEMENT ON 12TH OF SEPTEMBER 2022 – THE PROPOSAL



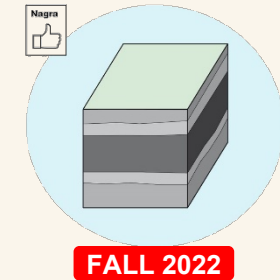
Siting process

Extensive underground investigation program completed successfully

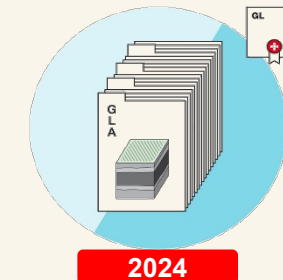


Nagra proposed

- a combined repository in Nördlich Lägern and
- **an encapsulation plant at the ZWILAG facility**

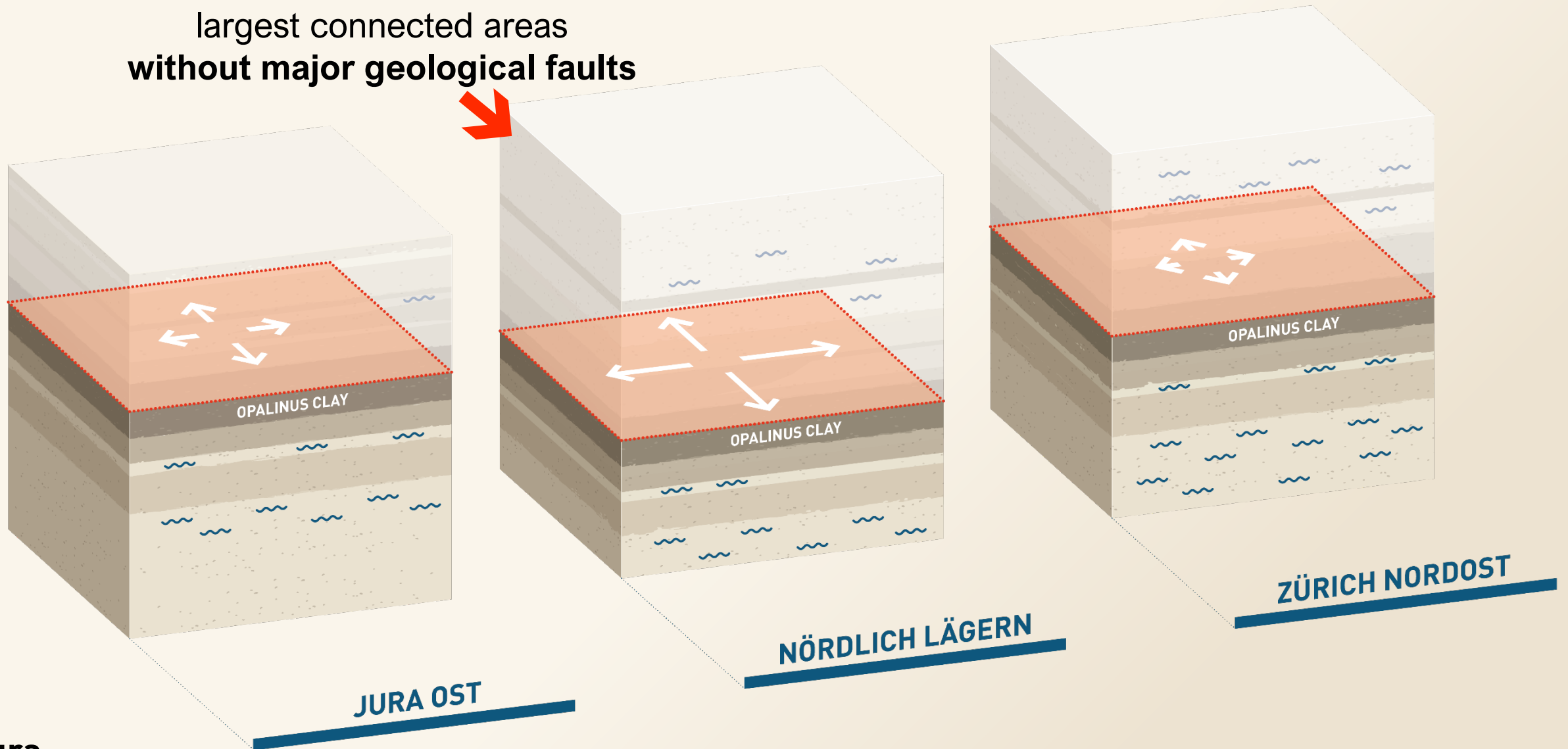


The general license application will be compiled until 2024/25



1. MAIN ARGUMENT: **FLEXIBILITY** FOR CONSTRUCTING A REPOSITORY

largest connected areas
without major geological faults

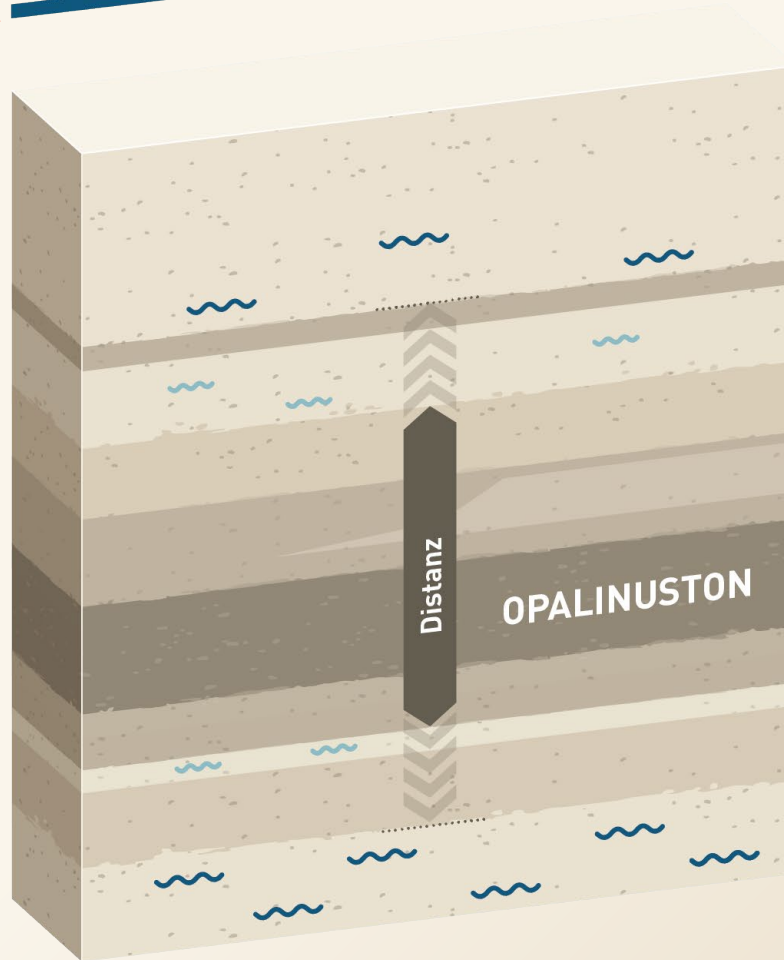
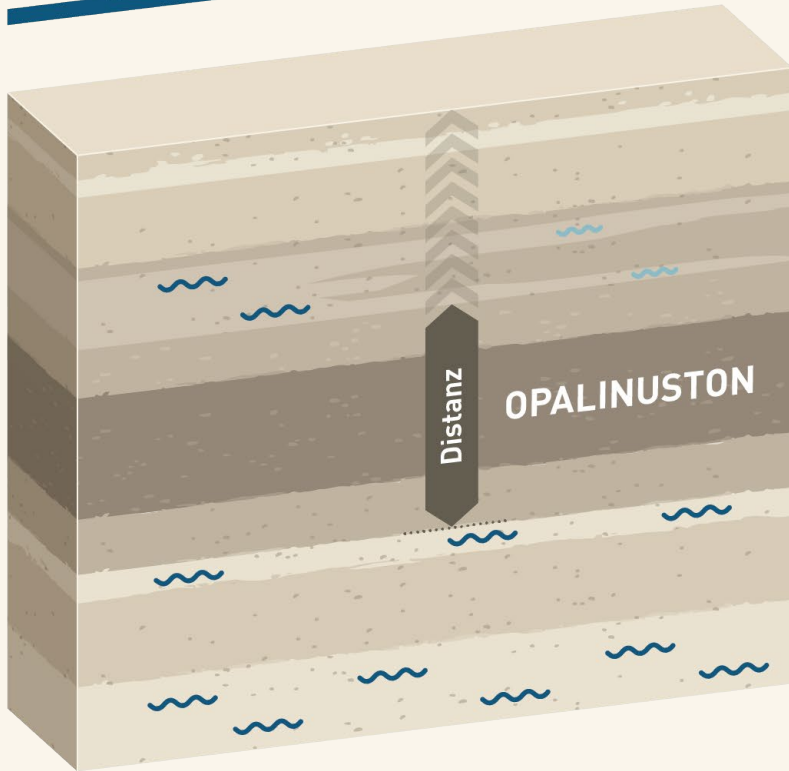


2. MAIN ARGUMENT: **QUALITY** OF GEOLOGICAL BARRIER

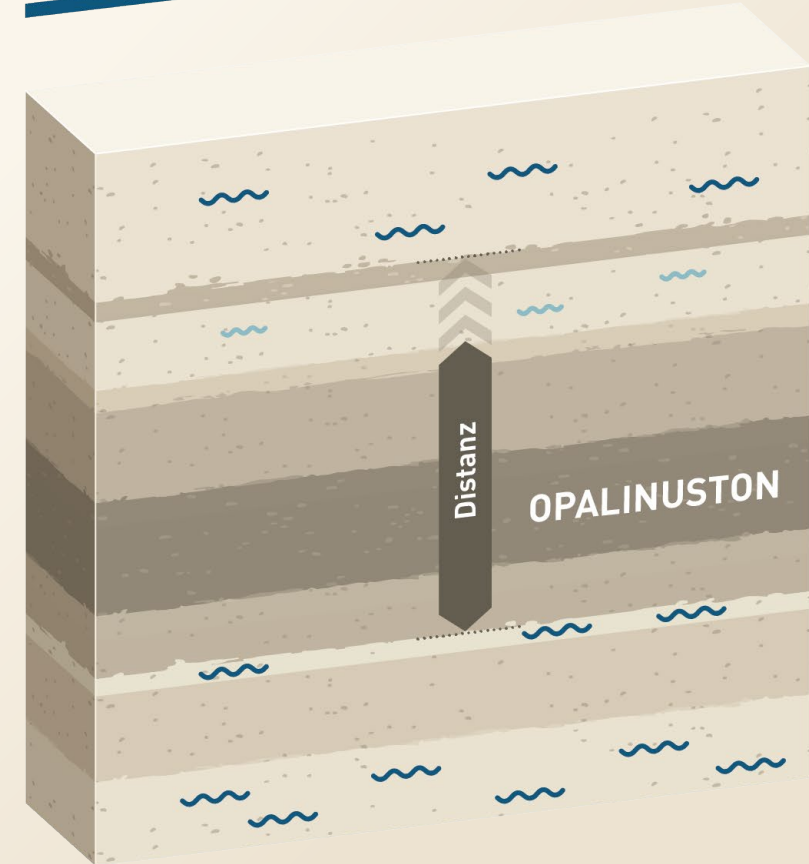
largest distance to
regional aquifers

NÖRDLICH LÄGERN

JURA OST



ZÜRICH NORDOST



Regional groundwater-bearing rock formation
Local groundwater-bearing rock formation

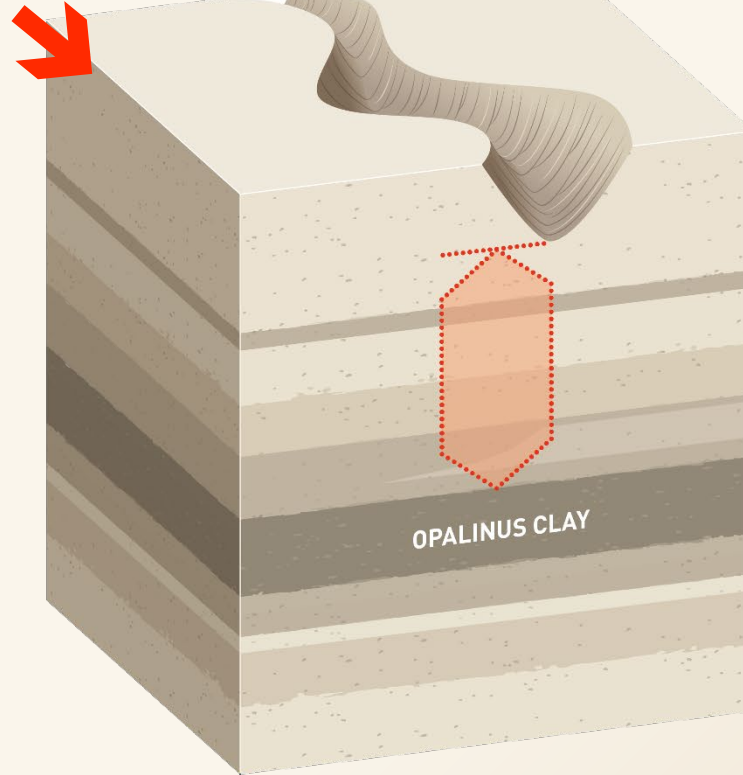
Distance to the nearest water-bearing rock formation
Indications of increased distance to the nearest water-bearing rock formation

3. MAIN ARGUMENT: **STABILITY** OF GEOLOGICAL BARRIER

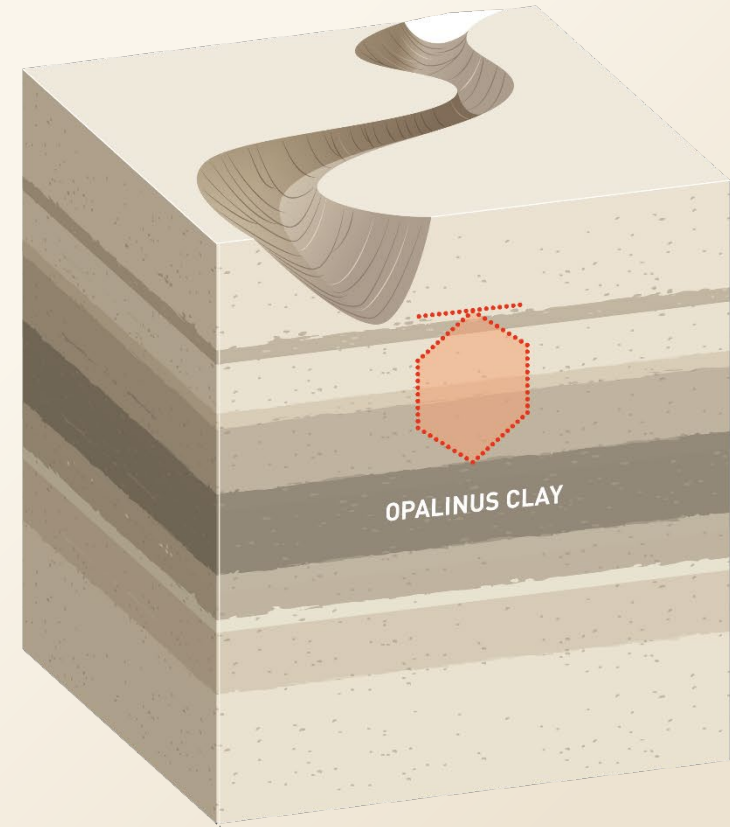
regarding erodibility
deeper is better



JURA OST



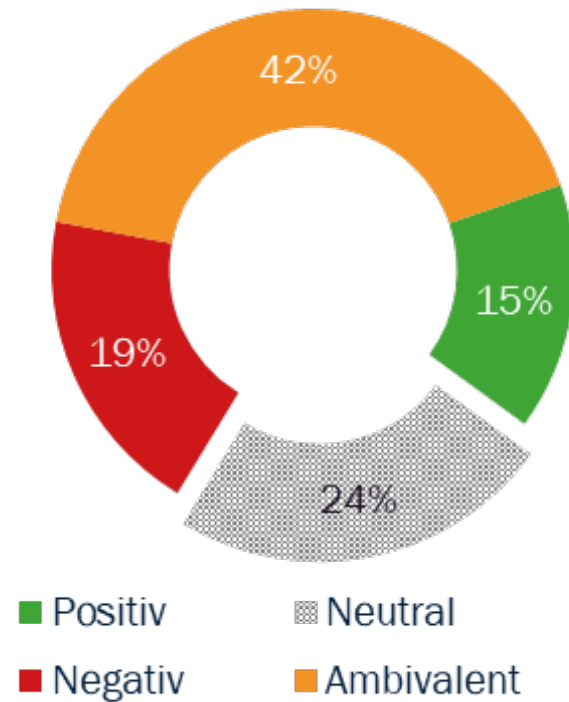
NÖRDLICH LÄGERN



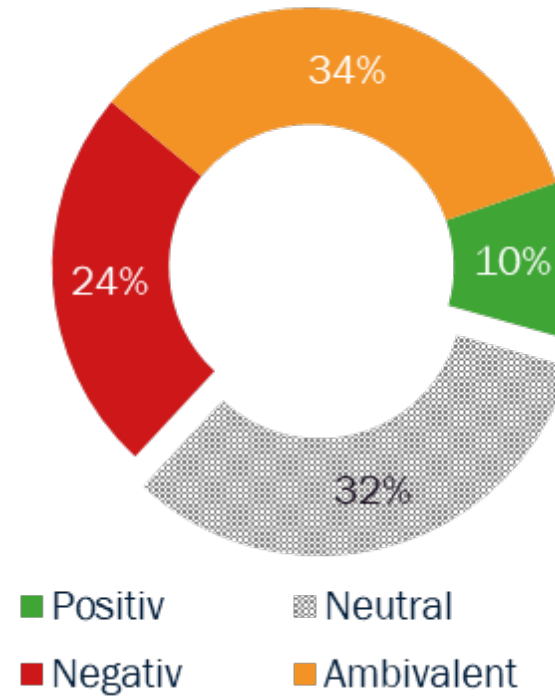
ZÜRICH NORDOST

MEDIA REACTION: TONALITY

**IN THE VICINITY
OF THE SITE**

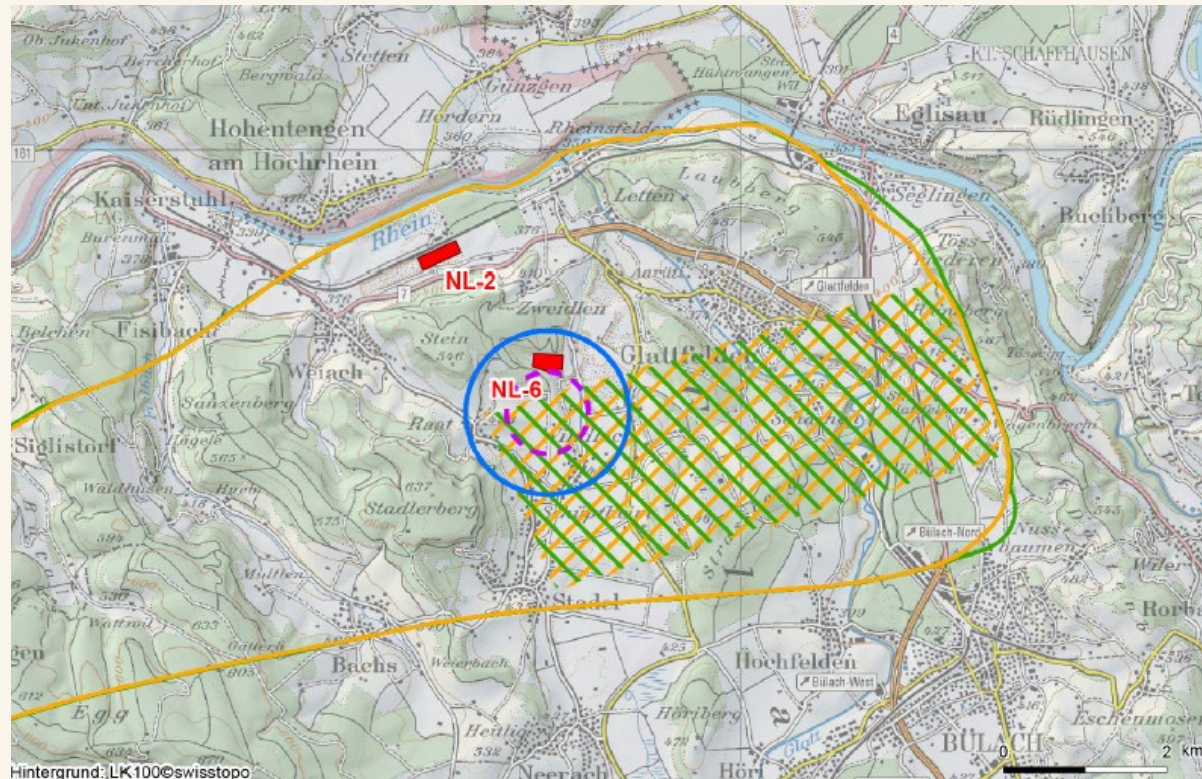


**FURTHER AWAY
FROM THE SITE**



PARTICIPATION - SURFACE INFRASTRUCTURE DEFINITION

In stage 2 & 3 of the Sectoral Plan, the surface infrastructure areas were defined



-  Area of surface infrastructure in Stage 2 of Sectoral Plan (core area with nuclear elements)
-  Area of additional surface infrastructure (construction shaft, ventilation shaft)



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REALISATION PLAN – COMBINED REPOSITORY

Major milestones:

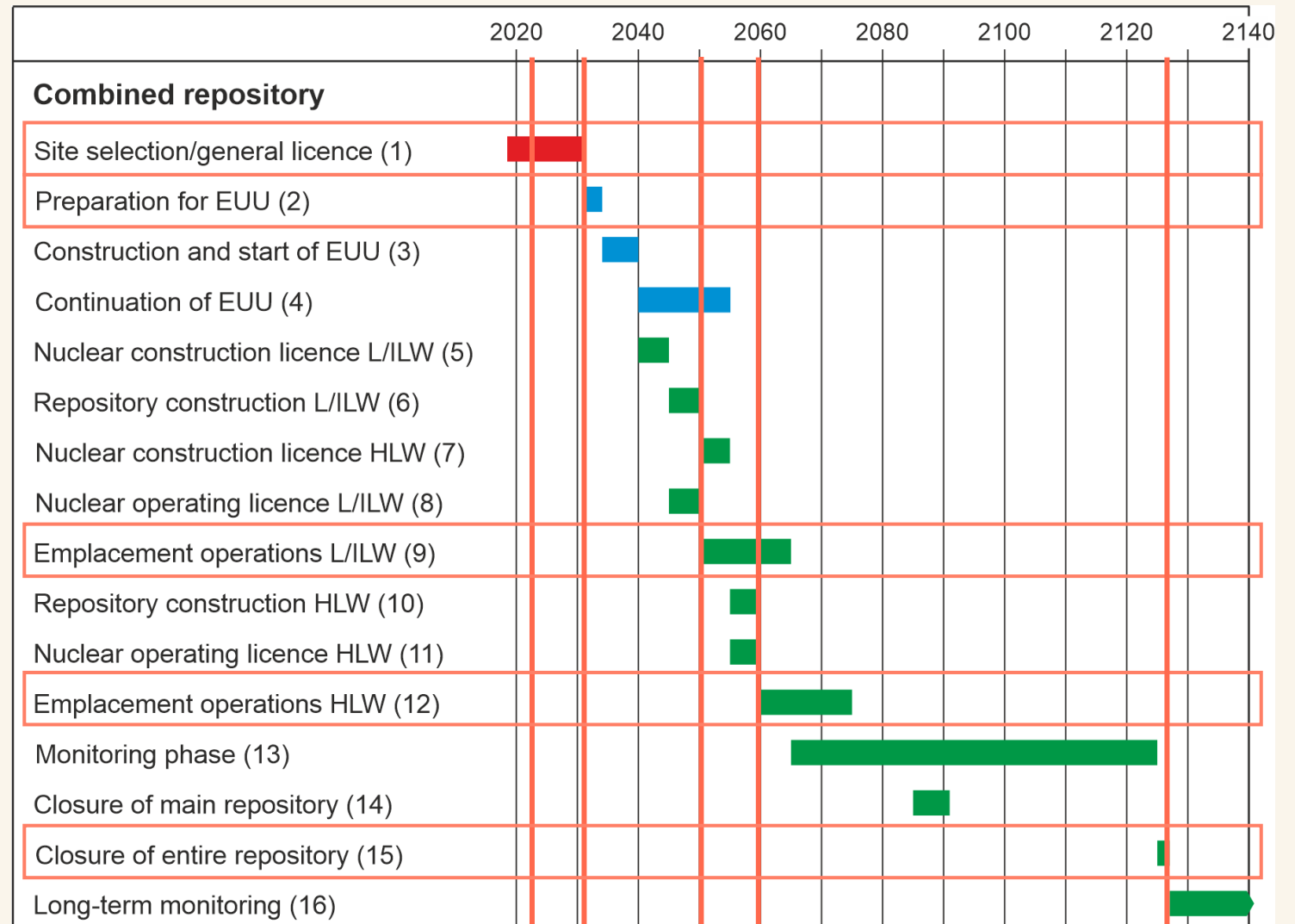
2024: General licence application

2033: Start of construction

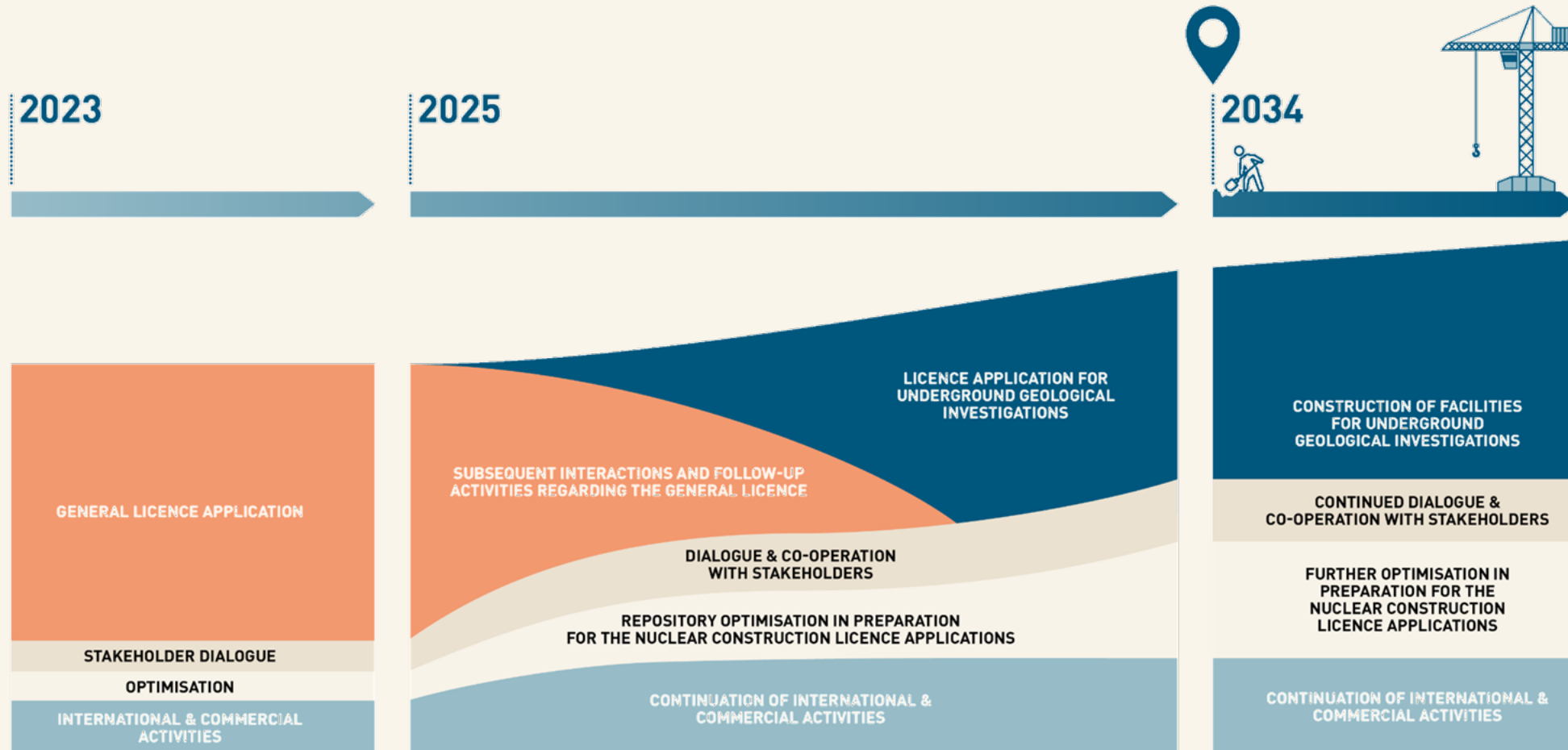
2050: Start emplacement (L/ILW)

2060: Start emplacement (HLW)

2127: Closure of entire DGR



TOWARDS CONSTRUCTION...



IMPORTANT FACTORS FOR DGR REALISATION

Generic aspects of the DGR

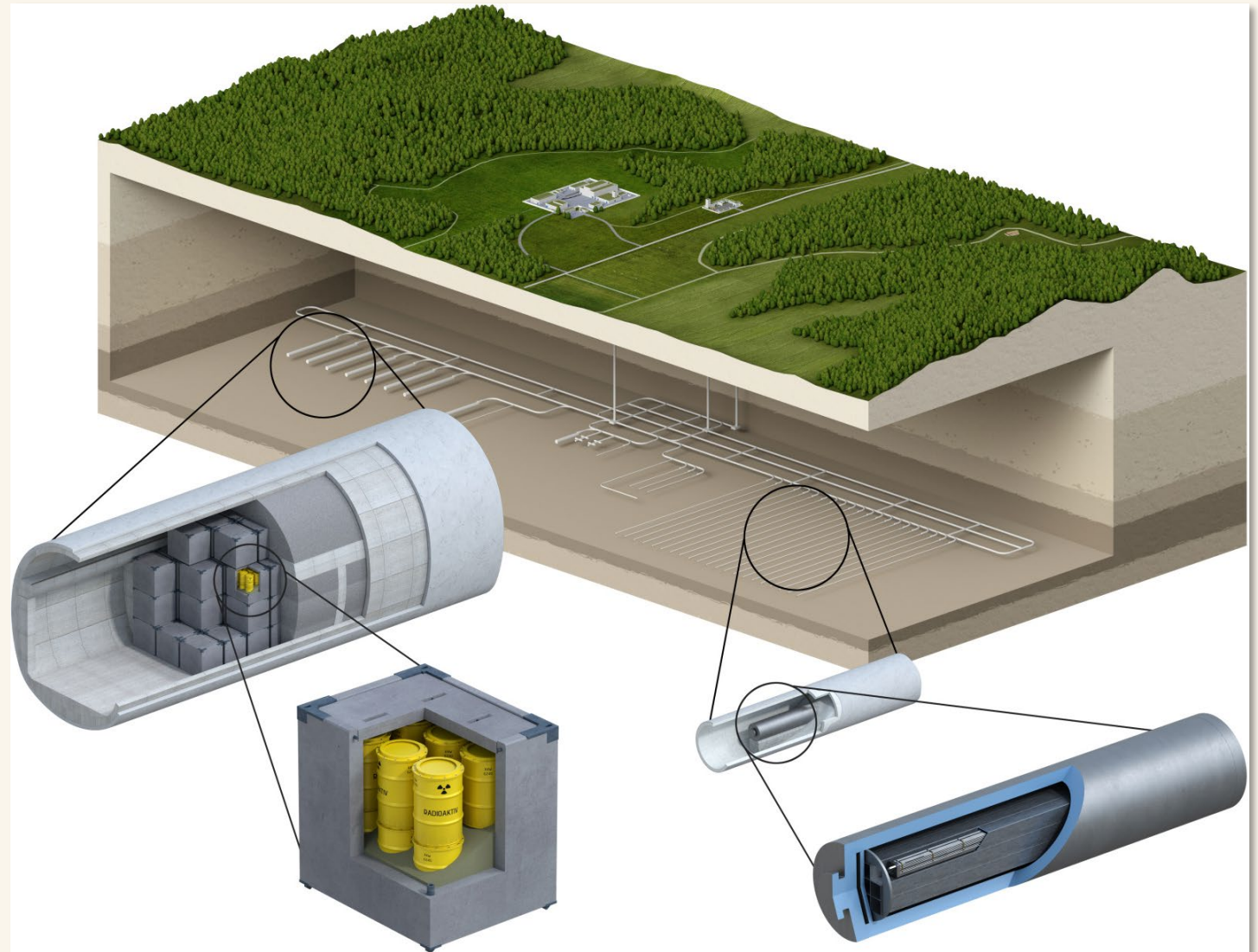
Site-specific facility planning

- Surface facilities
- Underground structures

Operational procedures

- Storage
- Backfilling
- Retrievability

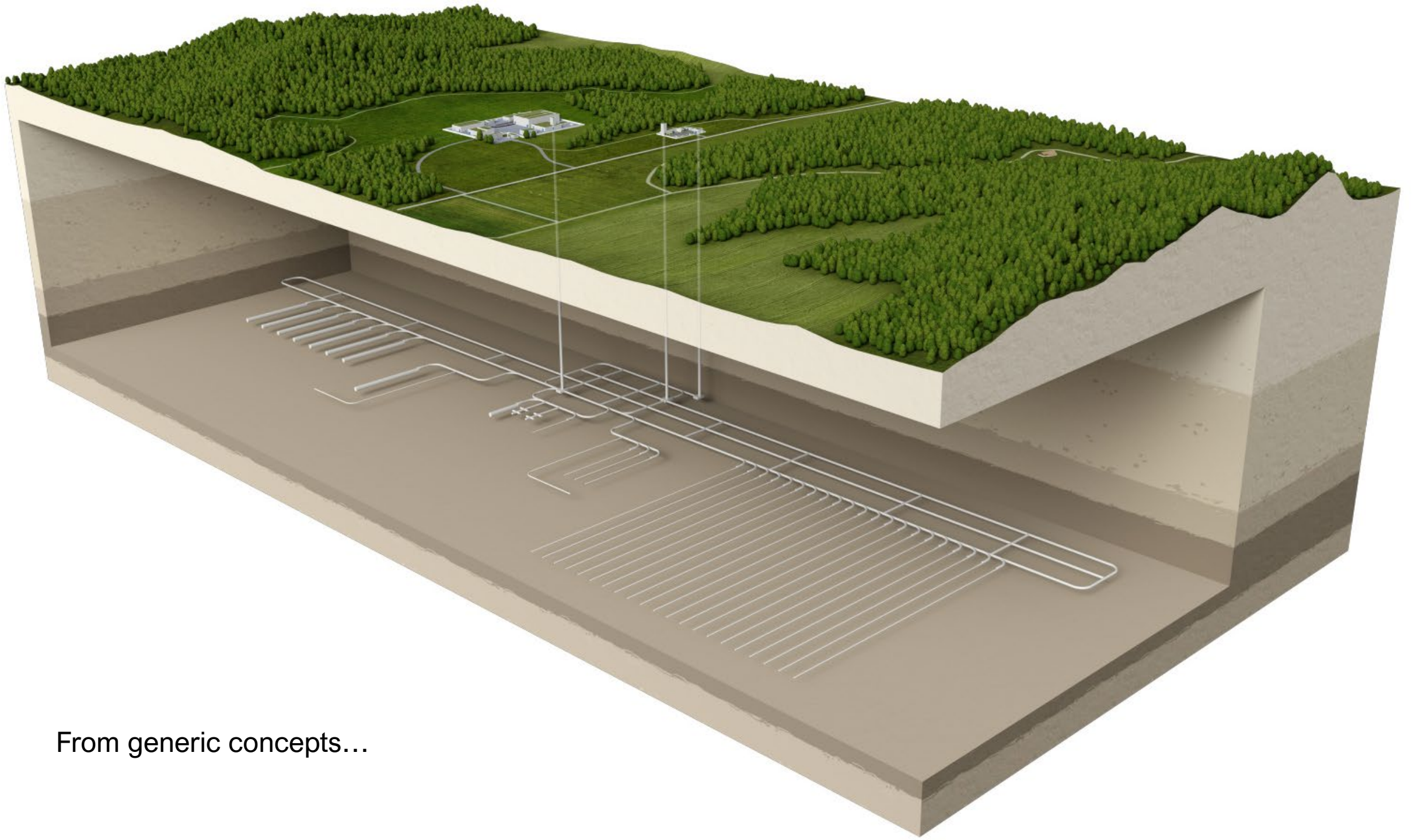
Environmental assessments



VISUALIZATION OF SURFACE FACILITIES



- Basis for further cooperation with regions and cantons
- Concretization / optimization of the arrangement of the facilities on the surface



From generic concepts...

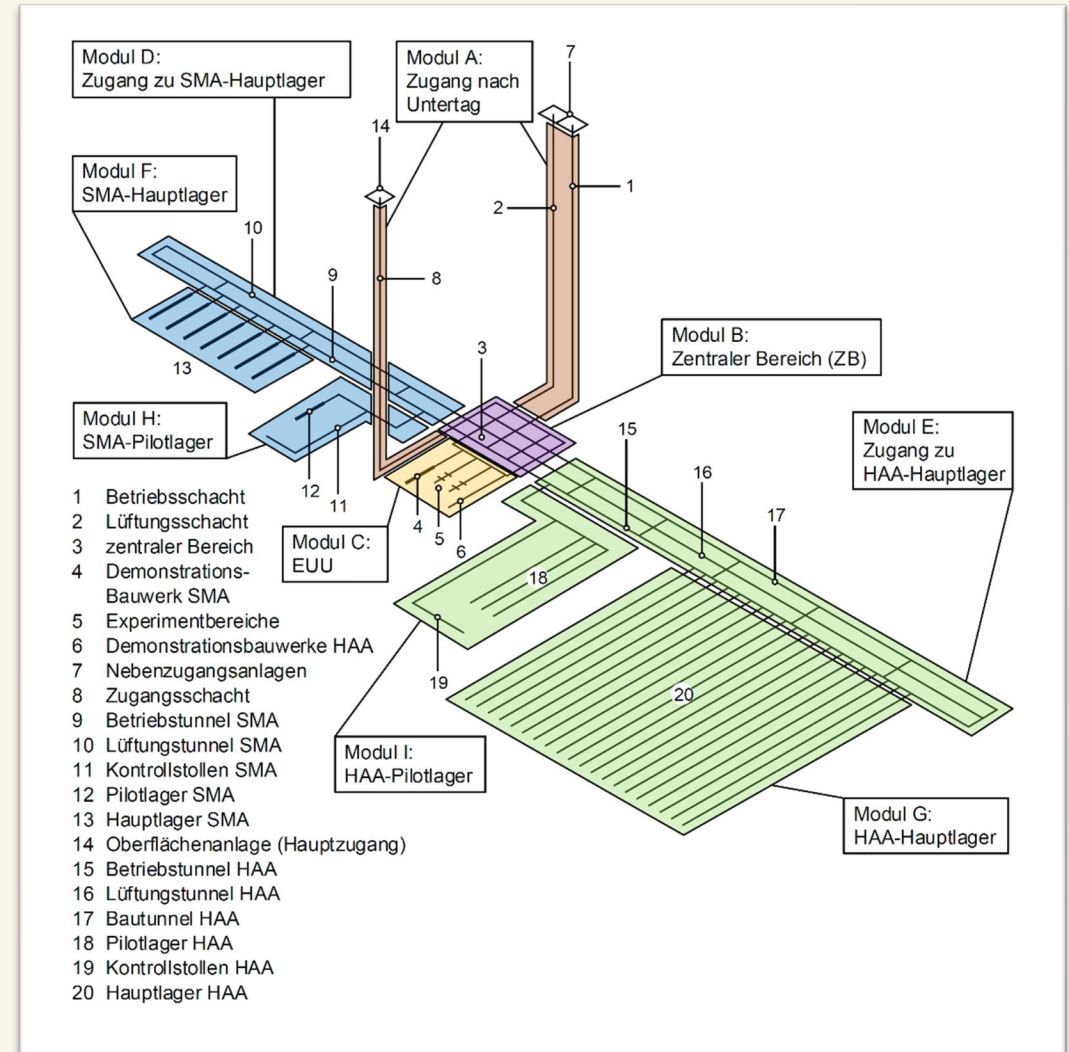
... to site specific layouts ...



ARCHITECTURE OF THE COMBINED DGR

Combined repository consists of

- Access facilities (shafts)
- Central area (logistics for operation and construction)
- Facilities for underground geological investigations
- L/ILW repository
- HLW repository



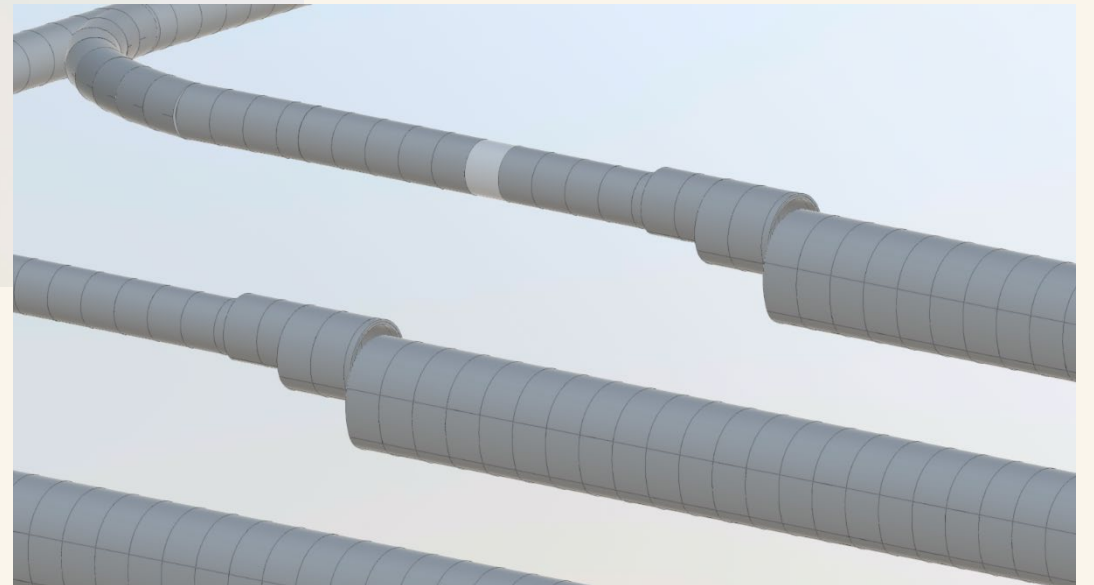
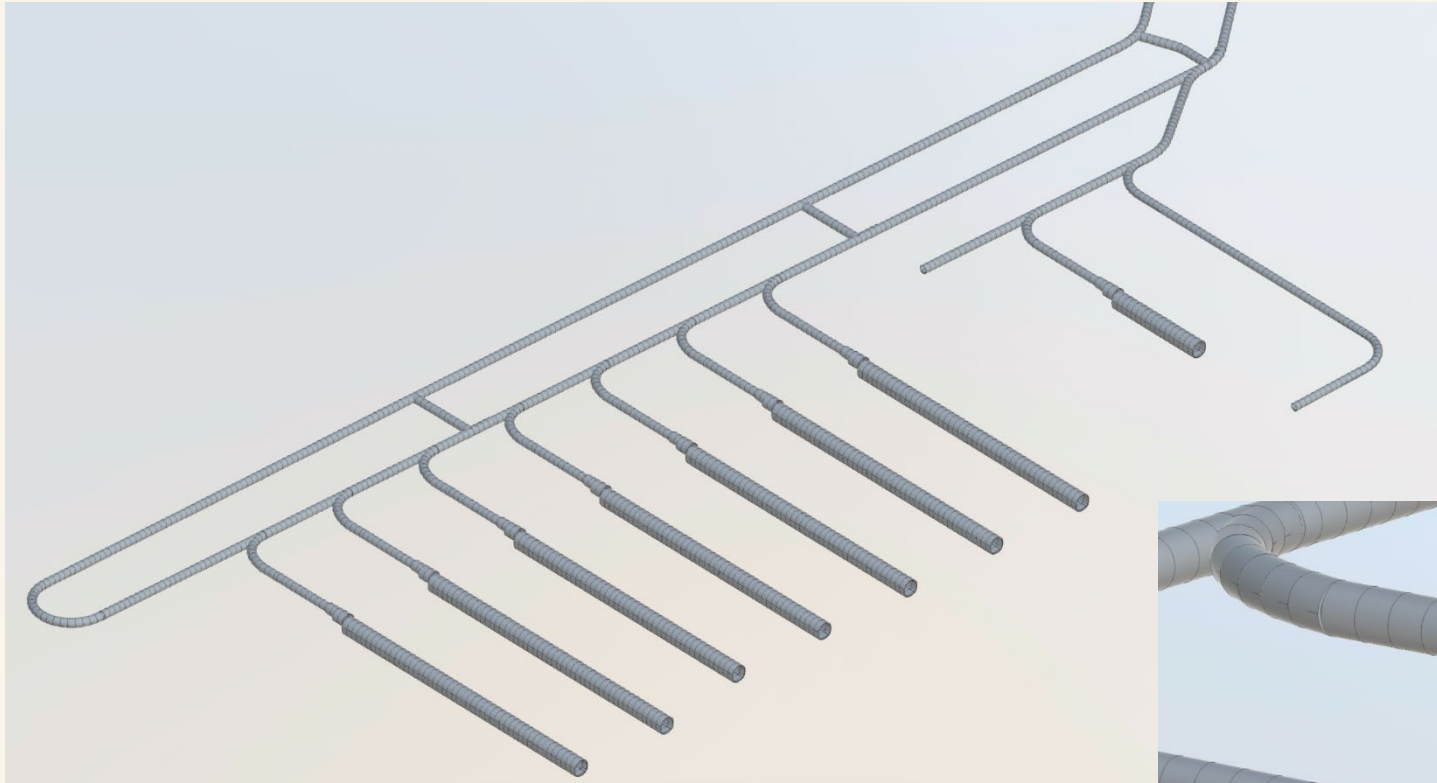
L/ILW REPOSITORY

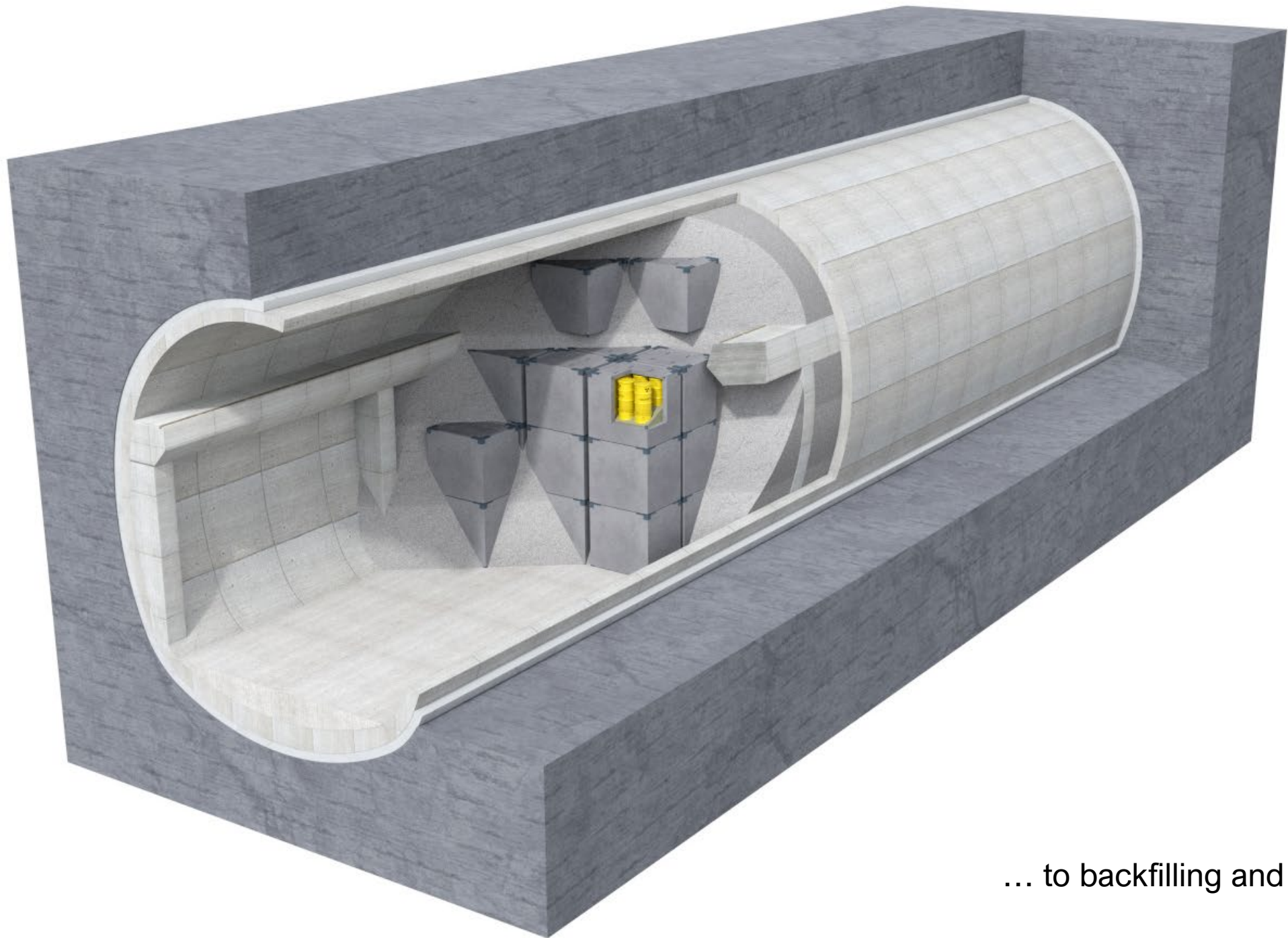
Main repository:

- 7 caverns
- Lengths of 230 to 245 m

Pilot facility:

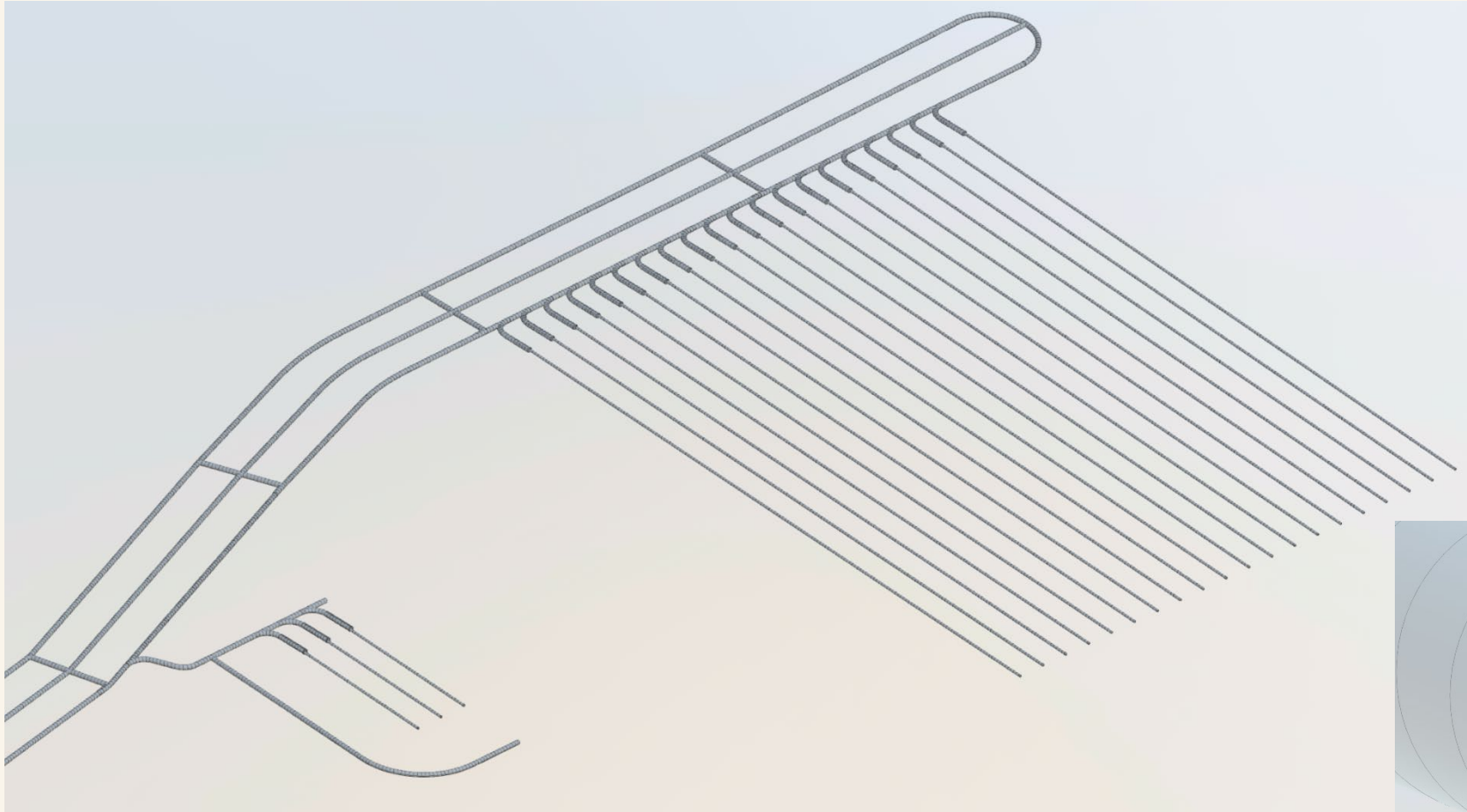
- 1 cavern
- Length 80 m





... to backfilling and closure!

HLW REPOSITORY

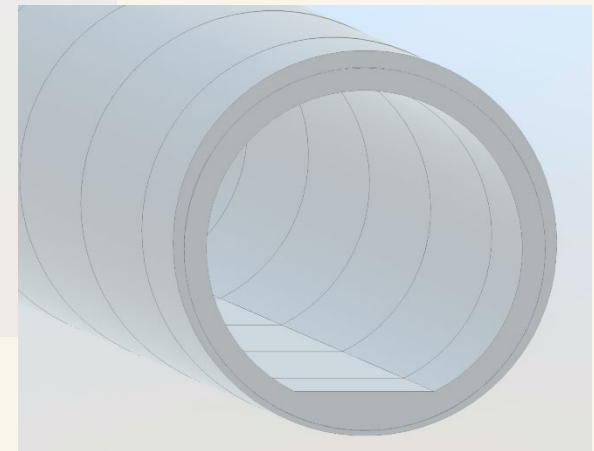


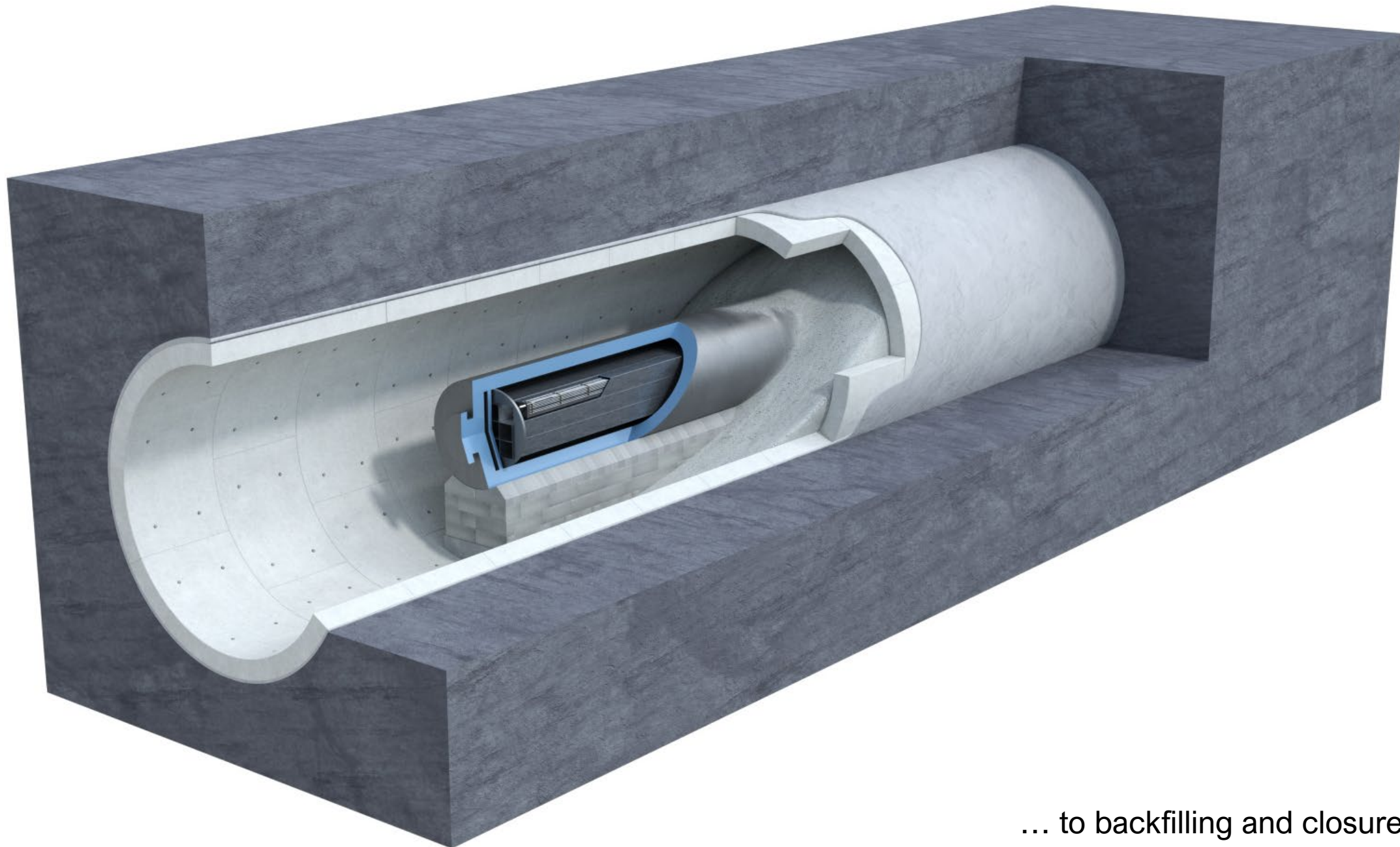
Main repository:

- 20 drifts
- Length of about 980 m

Pilot facility:

- 3 drifts
- Length of about 280 m





... to backfilling and closure!

KEY PRINCIPLES FOR ACHIEVING AND DEMONSTRATING LONG-TERM SAFETY

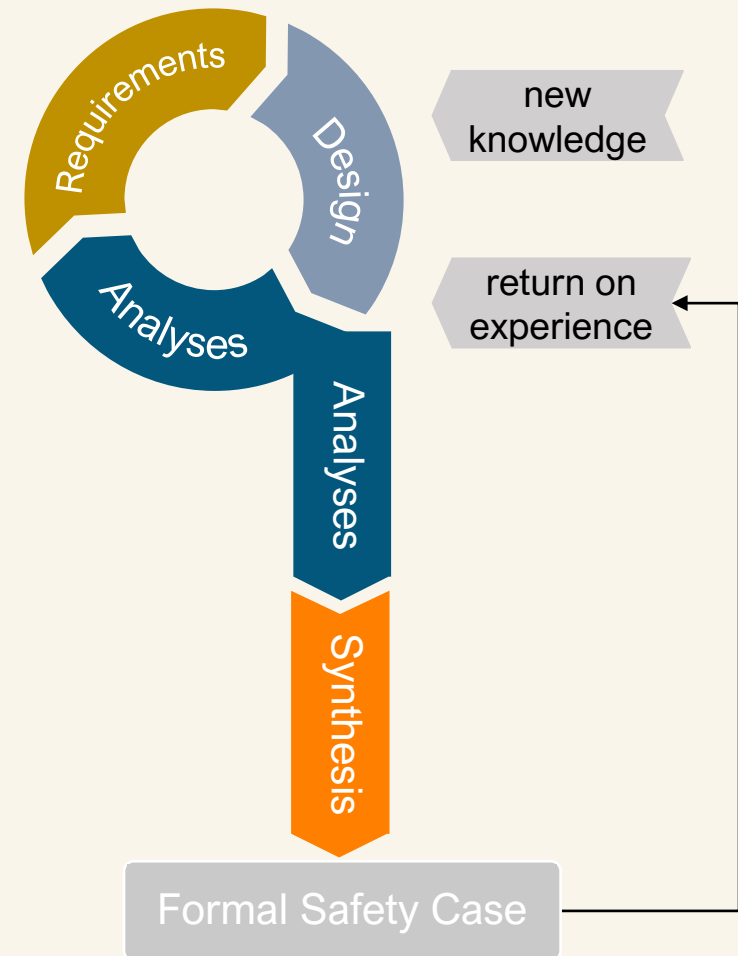
Safety is provided by a «good system»

- a passive multi-barrier system
- appropriate geology
- adequate engineered barriers (adapted to the geology)

The quality of the system is demonstrated by a «good analysis»

- quality (and completeness) of analysis
- good underlying scientific understanding
- regulatory safety criteria achieved

System development and safety demonstration is a step-wise iterative and transparent process



SUCCESS FACTORS OF SWITZERLAND'S RWM PROCESS

- Professional technical implementation and processes
- Secured financing
- Societal and political acceptance and willingness to implement measures
 - Clearly defined roles of the contributing actors: lead, project implementer, supervisory authorities, participants
 - Clear rules and transparent procedure: in Switzerland, safety has the highest priority
 - Dialogue at eye level: transparent and open
 - Balance between adaptability and rigid approach

