Engineered Barrier Systems (EBS): What are they for and how do they relate to the geosphere?

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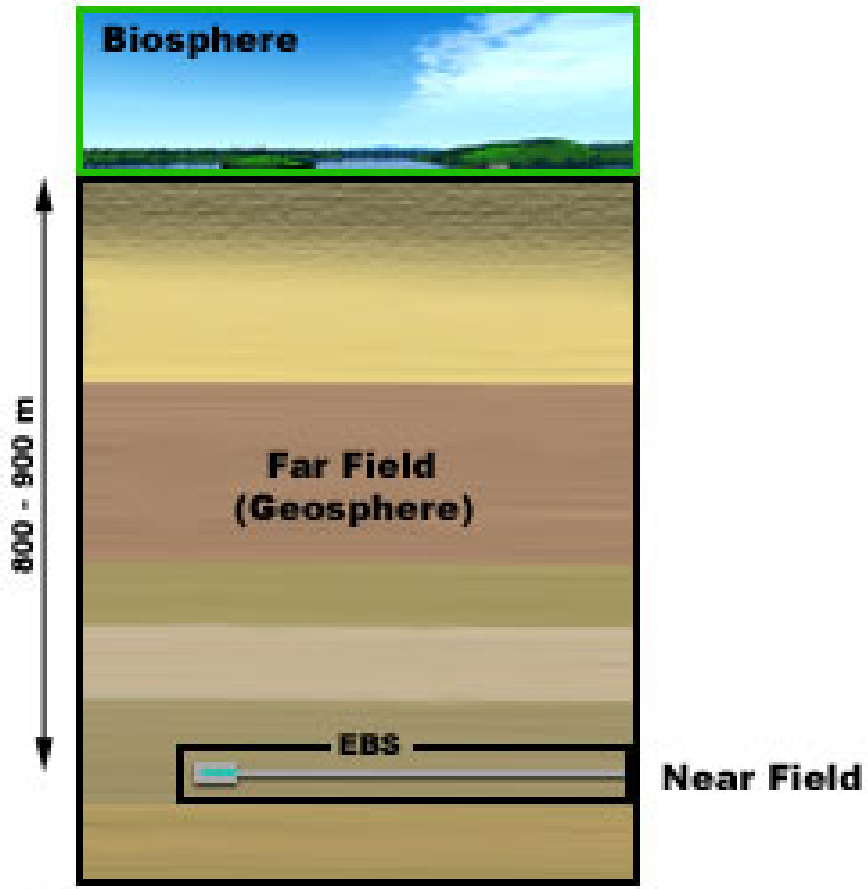


Schematic illustration from Nagra, Switzerland

Multi-barrier isolation and containment of waste

Multiple barriers increase confidence that waste will be isolated for a very long time, and also protected from human intrusion

An effective EBS design includes both physical isolation and chemical containment

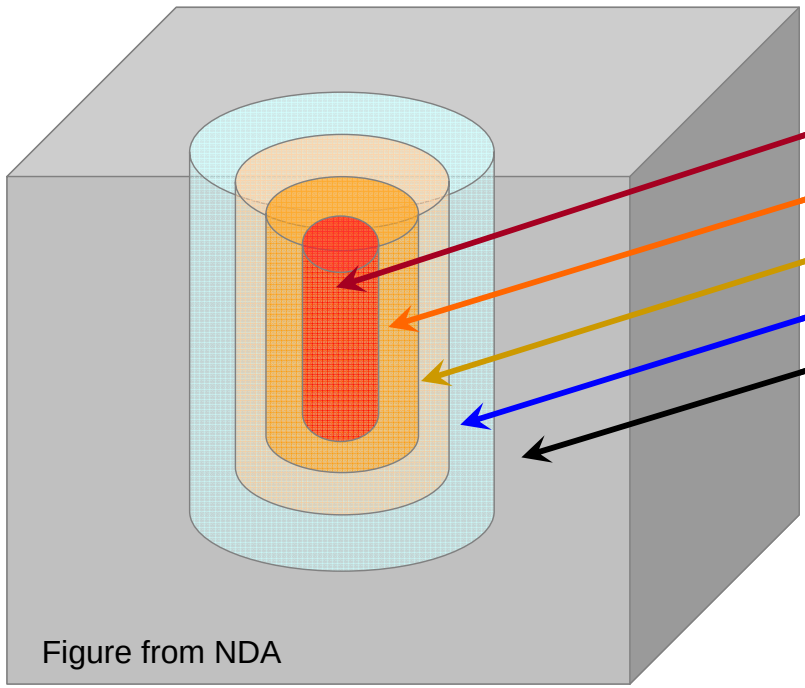


Figure from NDA

EBS has several components providing engineered isolation

Other parts of the EBS are the seals that plug tunnels and shafts

Some comments on the EBS

- Purpose of the EBS is to delay for as long as possible the release of radionuclides from waste into the surrounding rocks
- Geological disposal safety plans do not assume that total containment by EBS for ever is possible

The EBS and the host rock system work in concert

The advantage of physical and chemical containment is that the EBS is made resilient to a wider range of scenarios

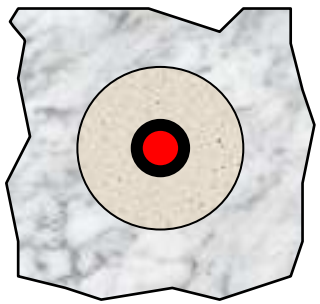
EBS design considerations

Various EBS designs are practicable for ILW and HLW-SF separately, depending on:

- Waste types and volumes of packaged waste
- Mechanical behaviour of host rock
- Heat that will be produced from HLW-SF
- Flux of groundwater at repository depth
- Interactions between waste materials and EBS
- Interactions between groundwater and EBS
- Evolution of the system into the future

EBS for different wastes

Waste Container &
Buffer or Backfill
in Tunnels or Boreholes
Spent Fuel/
HLW



c.5 metres

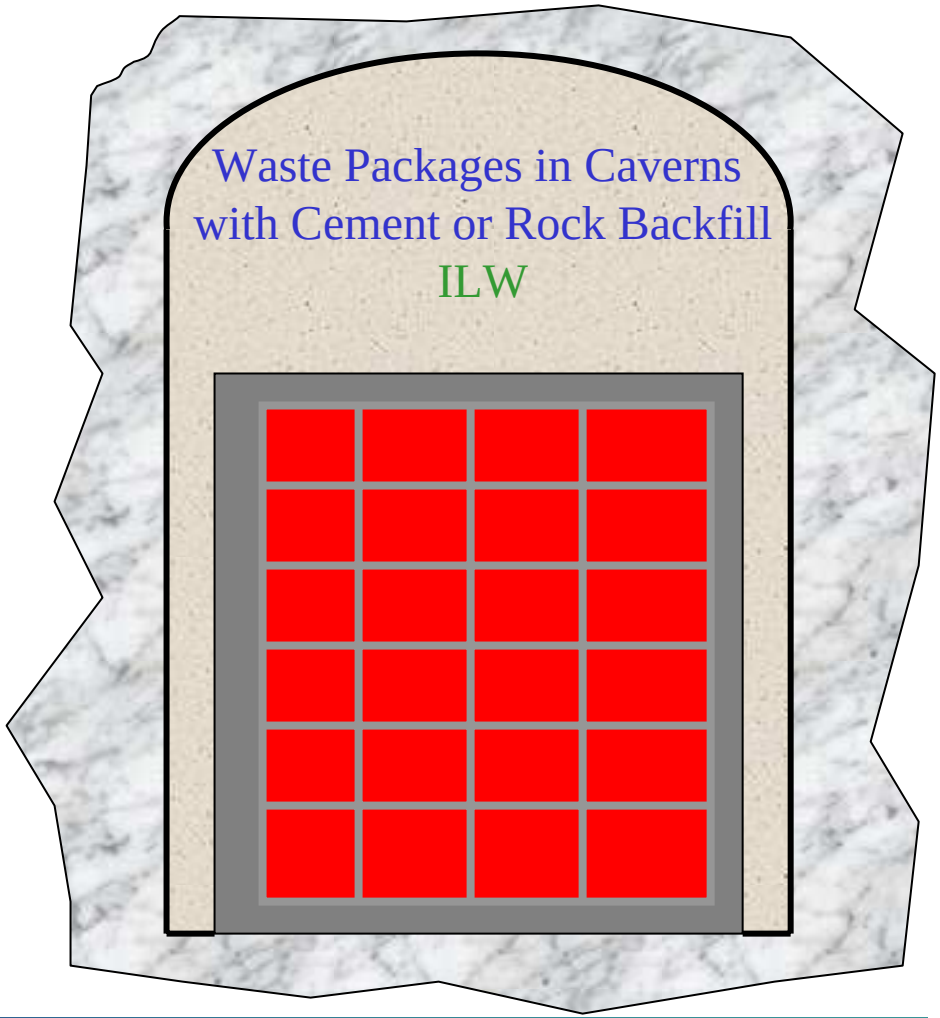
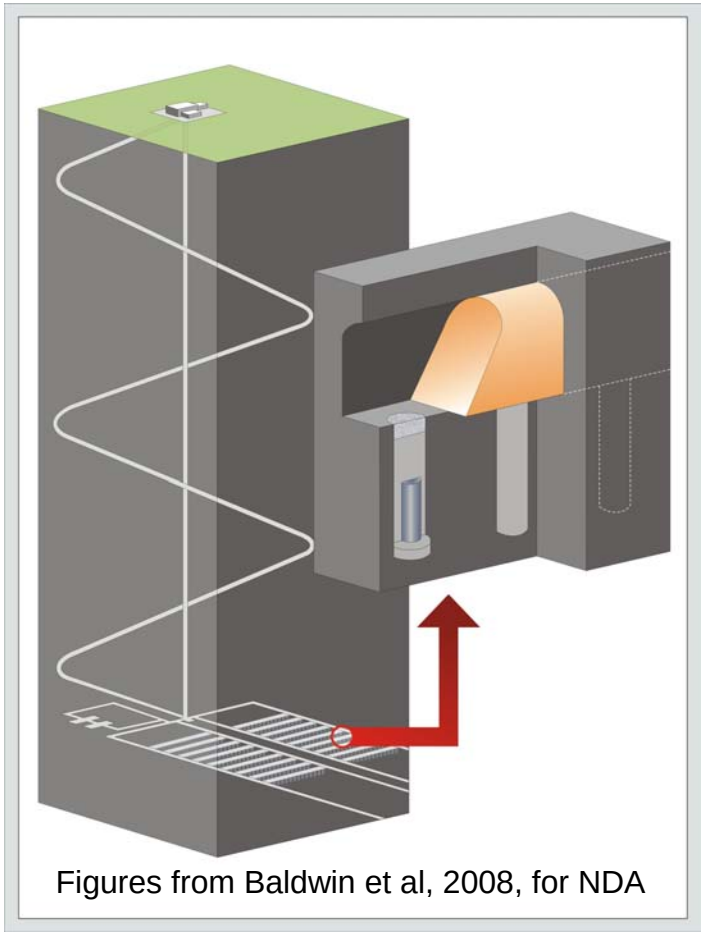
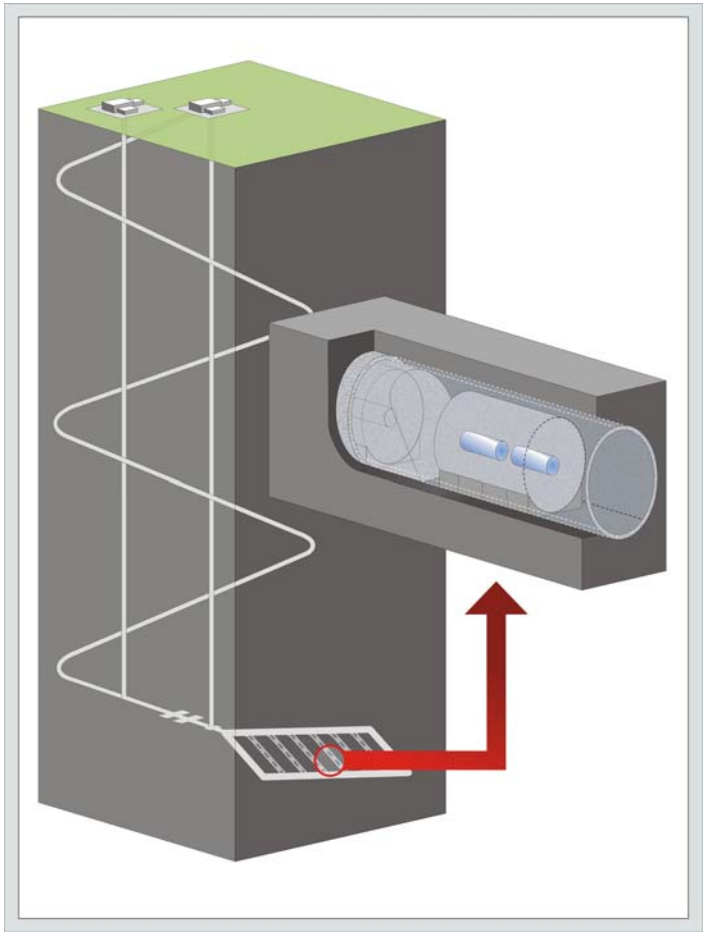


Illustration courtesy of N Chapman

A range of EBS designs for HLW-SF

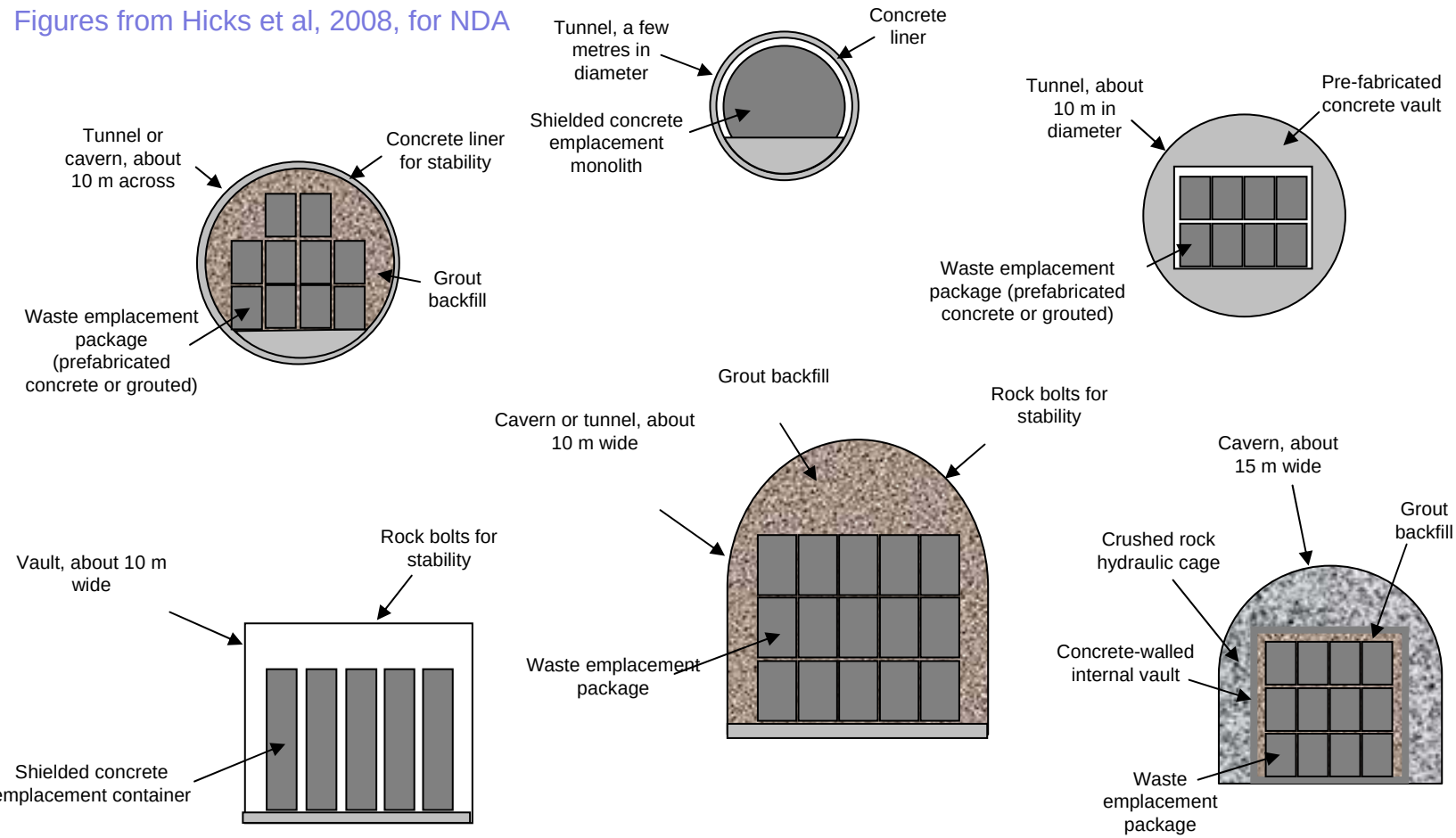


Figures from Baldwin et al, 2008, for NDA



A range of EBS designs for ILW

Figures from Hicks et al, 2008, for NDA



What does the host rock do for the EBS?

For the EBS to act as designed, a host rock formation should:

- Dissipate generated heat, i.e. have adequate thermal conductivity;
- Have low groundwater fluxes through the rock volume in which the facility will be excavated;
- Be mechanically stable, including attenuating or eliminating the impacts of external disruptive episodes such as earthquakes and glaciations;
- Provide groundwater chemical conditions that are favourable to the EBS;
- Dissipate gas by-products from waste degradation;
- Resist alteration by the transient high temperature of highly radioactive waste

Note that the properties relevant to hosting the EBS are not the sub-surface screening criteria for MRWS Stage 2 (cf. MRWS Implementation Framework, 2008, Annex C). They will be investigated in MRWS Stage 5.

Testing the properties of a potential host rock

Information about a potential host rock formation will be obtained to assess suitability, to test for unexpected anomalous conditions, and to provide site-specific data for a preliminary safety model calculation

thermal conductivity measured on rock cores from boreholes, also estimated theoretically from mineral composition

groundwater flow rates calculated with data for permeabilities and groundwater pressure from field tests

fractures or other zones of higher permeability rock that would intersect tunnels or deposition holes detected using geophysical surveys and borehole core logging

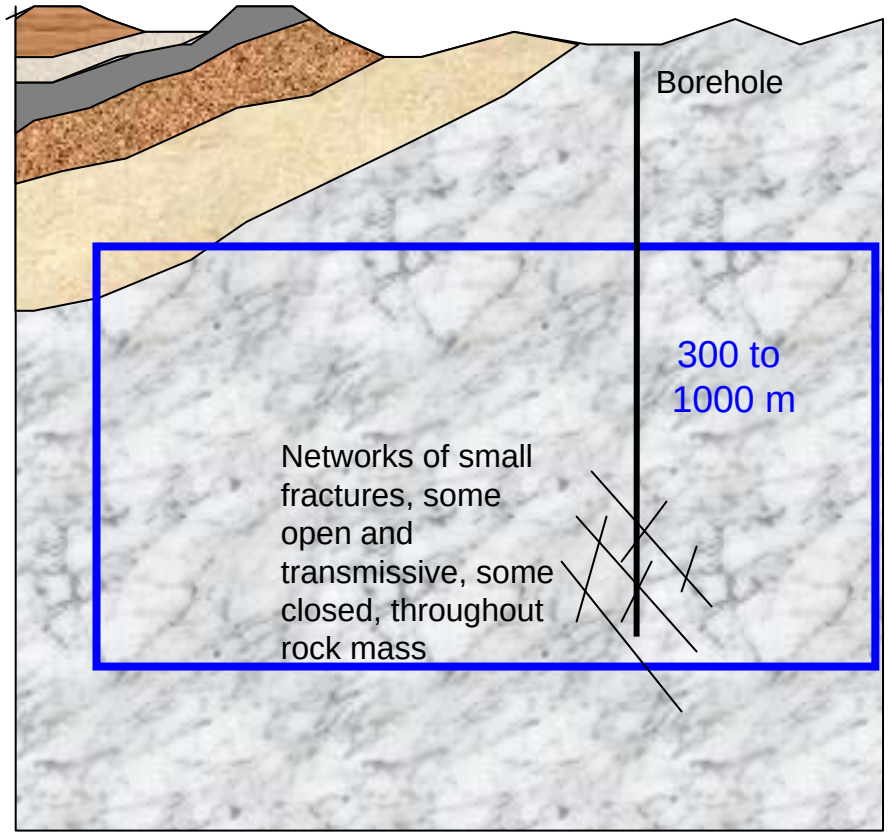
stress condition in rock measured by tests in boreholes and on borehole cores

strength of rock measured by laboratory tests on borehole cores

chemical compositions of groundwater analysed on samples extracted from host rock formation, e.g. for oxidation-reduction potential, pH and salinity that affect corrosion and other EBS degradation processes

Technology: Groundwater flow and permeability

Flow logging tool developed in Finland is able to measure water flow and permeabilities down to 10^{-10} metres per second over 1 metre test intervals



EBS design will be adapted to rock conditions

Examples of geological information and EBS design adaptability:

- fault zone through host formation
  - avoid putting deposition tunnels through fault zone
- weaker rock
  - design smaller tunnels and use rock support
- high rock stress
  - orient tunnels to minimise effects on long-term openings
- fracture zones with flowing groundwater
  - locate deposition holes to avoid fractures or grout them
- slightly more corrosive water (e.g. more saline, lower pH, less reducing)
  - design canister and buffer combination to be resistant

Summary

- An EBS is designed to contain wastes over the period when wastes are most radioactive
- Long-term safety will be achieved by designing EBS to act in concert with rock barrier
- The overall aim is to have a stable setting for EBS to work according to design for as long as possible
- Hydrogeological, mechanical, thermal and chemical properties of host rocks around EBS will be measured and their stability/evolution projected into future
- Location and design of facility will be adaptable within limits